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Microwaves & RF

News
2002 IEDM heralds emerging IC technologies

Design Feature
Single chip carries direct-conversion receiver

Product Technology
PC card holds Bluetooth analyzer

VNAs And Scopes Tackle Time/Frequency Domains

#BXNPGNX *********************AUTO**3-DIGIT 543
#533579017 5# RF 001 100 SCK 567
JOE LORITZ, ENGINEER
GBPPR
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GREEN BAY WI 54303-4115

Integrated-Circuits Issue

OCTOBER 2002 • VOL. 41 • NO. 10

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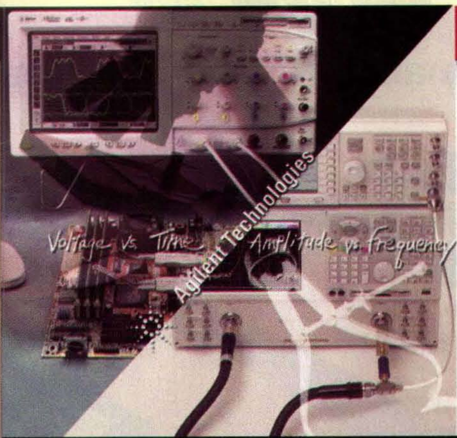

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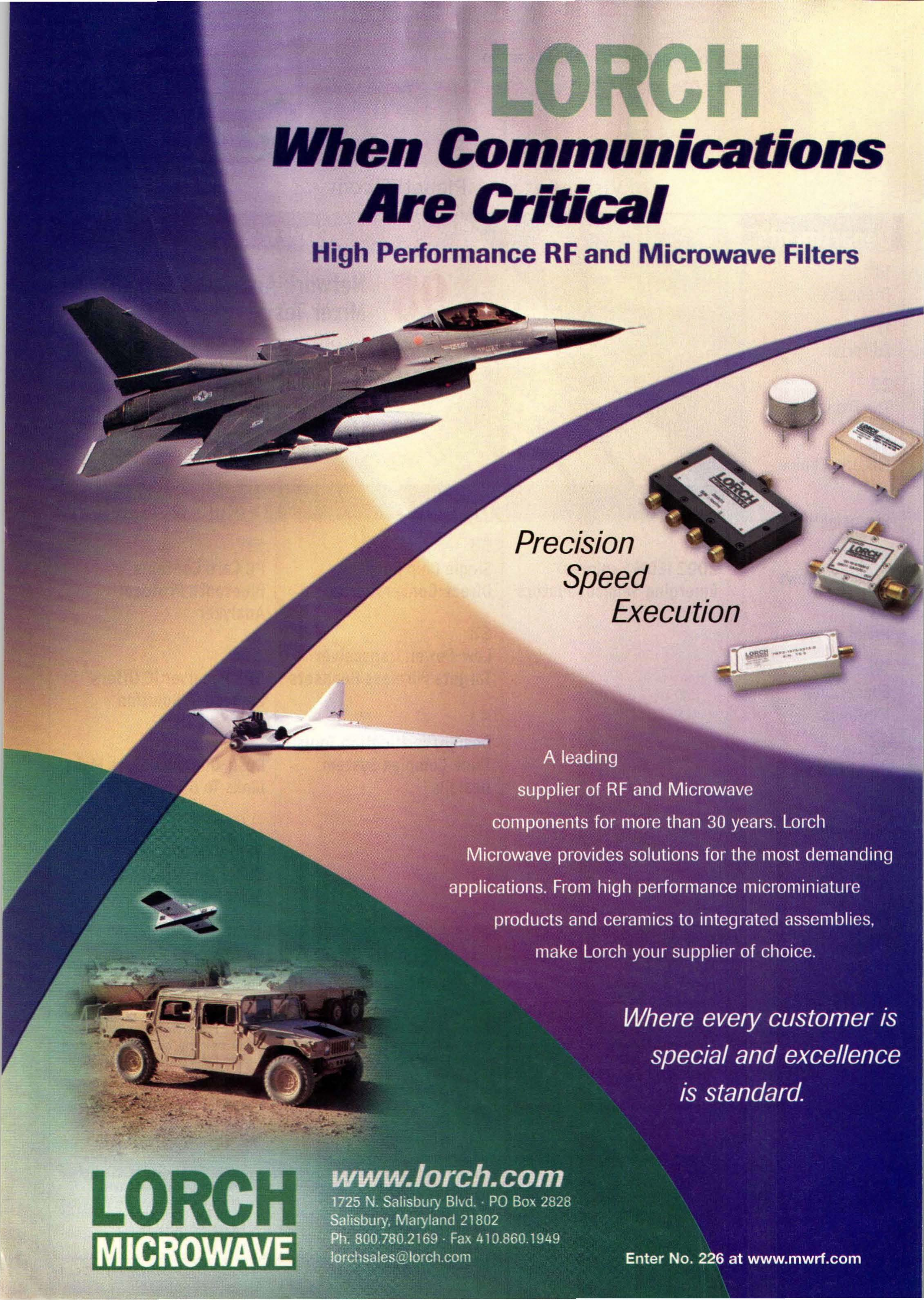
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A Correction

▶▶IN THE EDITOR'S CHOICE section of the June issue (p. 46), there was an error in the item about the series DFSS synthesizer from Elcom Technologies. The item read, "The DFSS synthesizer operates over the 1-to-15-GHz frequency range and provides 30-ms switching speeds." It should have read, "30 microseconds switching speeds."

Tara Goldberg
Elcom Technologies

Figure Error

▶▶AN ERROR APPEARED in Fig. 21 of my article entitled, "Setting Bias Points For Linear RF Amplifiers" Part 2 (July 2002, pp. 66-76).

It appears that when the figure was redrawn for publication, the legend line code for "Bias set via Pout" and Bias and Vcc set via Pout" was inadvertently switched, which changed the meaning of the plot and incorrectly conveyed that the performance of the RF5117 degraded when, in fact, the performance improved immensely.

Dave Dening
Senior Staff Engineer
RF Micro Devices

Caption Mistakes

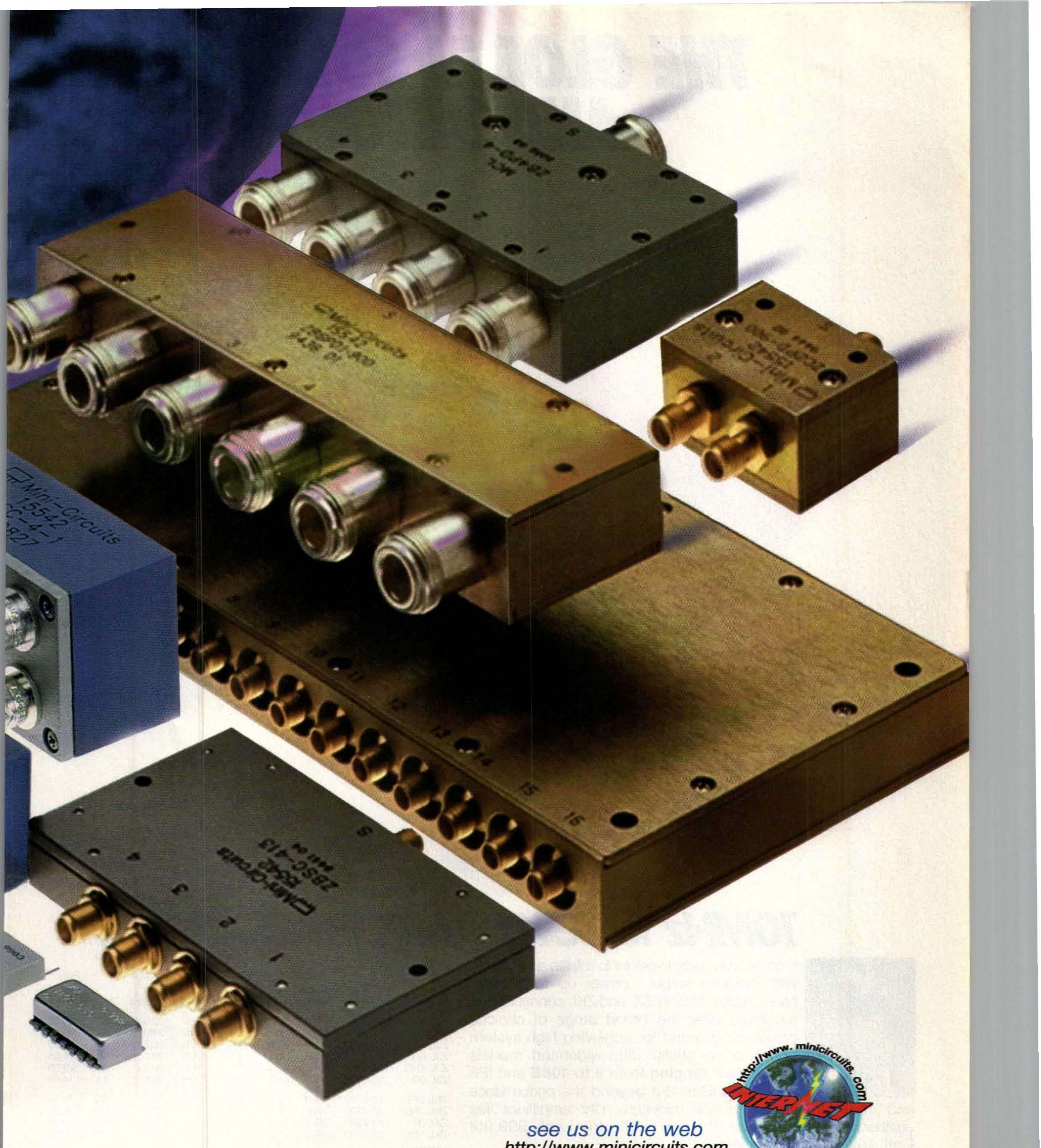
▶▶THANKS FOR PUBLISHING the article "Avoid Frequency Extrapolation Errors" in the September issue (p. 98). We appreciate the exposure that this brings to us.

Unfortunately, I found several errors in the figure captions. They are:
Fig. 3: "(thick black line)" should read "(thick green line)"; "(magneta circles)" look more like red squares and "(blue squares)" look like "(black squares.)"
Fig. 4: "(thick black line)" looks like a "(thick red line)"; "(magneta circles)" are "(black squares)" as printed; "(blue squares)" are "(green squares)" as printed.
Fig. 5: "(magneta circles)" are "(black squares)" as printed and "(blue squares)" are "(red circles)" as printed.
Fig. 6 and Fig. 7: "(blue circles)" are "(green circles)" as printed.
Fig. 8: "blue circles" are "blue crosses."

Larry Dunleavy
Modelithics, Inc.

Editor's Note

▶▶MICROWAVES & RF apologizes to the authors of the articles mentioned above for the errors that occurred. We would like to thank those who pointed out these errors. We hope that the corrections that have been published here are beneficial to our readers.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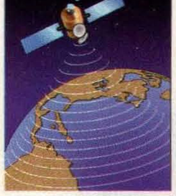

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ZJL-5G	20-5000	9.0	±0.55	15.0	8.5	32.0	80	129.95
ZJL-7G	20-7000	10.0	±1.0	8.0	5.0	24.0	50	99.95
ZJL-4G	20-4000	12.4	±0.25	13.5	5.5	30.5	75	129.95
ZJL-6G	20-6000	13.0	±1.6	9.0	4.5	24.0	50	114.95
ZJL-4HG	20-4000	17.0	±1.5	15.0	4.5	30.5	75	129.95
ZJL-3G	20-3000	19.0	±2.2	8.0	3.8	22.0	45	114.95
ZKL-2R7	10-2700	24.0	±0.7	13.0	5.0	30.0	120	149.95
ZKL-2R5	10-2500	30.0	±1.5	15.0	5.0	31.0	120	149.95
ZKL-2	10-2000	33.5	±1.0	15.0	4.0	31.0	120	149.95
ZKL-1R5	10-1500	40.0	±1.2	15.0	3.0	31.0	115	149.95

NOTES:
1. Typical at 1dB compression.
2. ZKL dynamic range specified at 1GHz.
3. All units at 12V DC.

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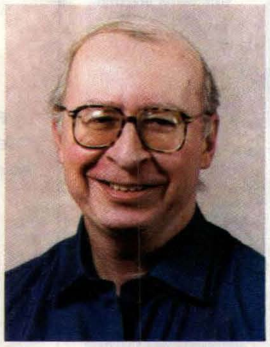
Studying Wireless Reference Designs



REFERENCE DESIGNS REPRESENT the ultimate "how-to" guide for engineers in need of fresh ideas. Although generic by nature, a reference design is usually a complete implementation of a wireless product, providing an engineer with a "legal" opportunity of reverse-engineering a proven layout or IC bias configuration. Of course, the reference design is generally based upon IC products from a single supplier, and it does not include open "slots" for evaluating ICs from other vendors. Still, the circuitry has been optimized for a specific set of ICs, and has been thoroughly tested for reliable operation with those semiconductors.

Reference designs and their accompanying documentation are an important part of a total wireless engineering education.

Who can benefit from studying a reference design (other than the vendor trying to sell the design's ICs)? Basically, any wireless engineering designer tasked with developing higher-level (board-level and beyond) solutions can learn something from a reference design that can be directly applied to a design problem or modified for use with the same set of ICs or devices from other suppliers.

Reference designs and their accompanying documentation are an important part of a total wireless engineering education. Unfortunately, they are often ignored as educational tools. They have been omitted from presentations at "serious" technical conferences, including the Wireless Systems Design Conference and Expo (formerly the Wireless Symposium & Exhibition). But beginning with the 2003 event, the Wireless Systems Design Conference will not only include reference designs, it will feature reference-design presentations as a key component of the technical program.

Already, suppliers of semiconductors, including such respected firms as California Eastern Laboratories and Fujitsu Microelectronics, have expressed interest in offering presentations on reference designs, including DSP boards, GPS Rxs, and WLAN systems.

Basically, each reference-design presentation will pack a great deal of information into a half-hour. Each presentation will offer attendees a chance to travel through a design layout, examine a bill of materials (BOM) for the additional components required, review test procedures for the reference design, and discuss details of the design with the presenter. A moderator will be present to discourage companies from turning these technical sessions into sales presentations.

Ideally, a full technical track on reference designs would cover a wide range of wireless applications, including Bluetooth, digital radios, DSPs, GPS, PCS handsets, RFID designs, WLANs, and even UWB transceivers. Design engineers involved with wireless reference designs are potential presenters, and are encouraged to e-mail their ideas for a presentation to this editor at jbrowne@penton.com.

Jack Browne

Publisher/Editor

Microwaves & RF

A Penton Publication

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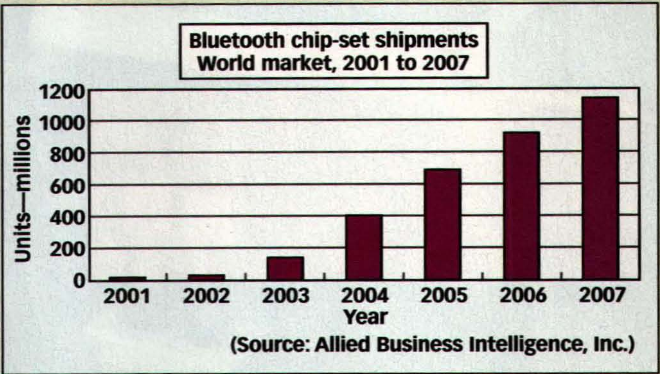
the front end

News items from the communications arena.

Long-Term Prospects For Bluetooth Are Improving

OYSTER BAY, NY—Bluetooth finally appears to be on the brink of fulfilling its considerable potential, evidenced by steady market growth during 2002. An Allied Business Intelligence (ABI) report, "Bluetooth—The Global Outlook for Bluetooth Component and Equipment markets," projects Bluetooth chip-set shipments to increase to 33.8 million in 2002, up from 11.2 million in 2001. In the longer run the Bluetooth semiconductor market is forecast to grow to just over 1.1 billion chip sets by 2007 **(see figure)**, with associated revenues of $2.54 billion.



In retrospect many of the problems encountered in 2001 were those that ABI cautioned about. Probably the single biggest issue with the Bluetooth story was hype. However, the hype in the Bluetooth space has largely been replaced by a considerably more pragmatic perspective, with an understanding of the technology's limitations. Other problems have also been alleviated. The Bluetooth 1.1 specification is fairly stable, interoperability issues are far fewer, and aggressively priced chip sets are available from several vendors.

"Given the commitment of the mobile handset vendors to Bluetooth, we expect cell phones to account for approximately two-thirds of the projected 27.8 million Bluetooth devices that will ship in 2002," commented Navin Sabharwal, ABI's director of Residential and Networking Technologies and the report's author. "However, 2003 should see volume shipments ramping up across a number of other market segments."

More Foreign Nationals Are Enrolling In Engineering Courses

WASHINGTON, DC—The number of foreign nationals enrolling in engineering bachelor's degree programs is increasing significantly according to a recently released report from the Engineering Workforce Commission (EWC). According to data in *Engineering & Technology Enrollments, Fall 2001*, the enrollment level of foreign national students rose 18.6 percent at the freshman level and 14.7 percent at the graduate level.

While the number of women enrolled in engineering continues to climb, they are not keeping pace within the freshman class. In 2001, female students declined as a percentage of engineering freshmen, falling from 18.9 to 18.3 percent of the freshman class. This downward trend has been developing over the last five years. However, women are still increasing in number and percentage at the graduate level (from 10.0 to 10.3 percent at the master's level and from 6.2 to 6.6 percent at the doctoral level).

Enrollments in bioengineering and general engineering programs rose and computer enrollments continued an upward trend. Chemical-engineering enrollments declined, while electrical engineering remained virtually unchanged for the year. Total freshman enrollments in all engineering disciplines are up 5.0 percent from 2000, master's enrollments are up 5.4 percent, and doctoral enrollments are up 8.3 percent.

Engineering & Technology Enrollments, Fall 2001 includes data on enrollments for engineering and engineering-technology programs at more than 500 US ABET-accredited colleges and universities.

Motorola Automates Akron's 3-1-1 Non-Emergency Calls

SCHAUMBURG, IL—Motorola, Inc. has announced that the city of Akron, OH has selected Motorola's Customer Service Request (CSR) system to automate and greatly enhance Akron's service delivery citywide, as well as across departments and its call-center operations. The new CSR system is part of Motorola's portfolio of integrated communications and information solutions to address mission-critical public safety and security requirements worldwide.

Akron is the first city in Ohio to purchase the CSR 3-1-1 system, enabling city personnel to handle an annual average of 400,000 calls for non-emergency service requests and information.

"The CSR system will enable us to achieve our vision of providing citizens quicker access to the city's services 24 hours a day."

"The CSR system will enable us to achieve our vision of providing citizens quicker access to the city's services 24 hours a day throughout the year," said Mayor Donald Plusquellic of Akron. "This system is the key to our ongoing efforts to deliver to our citizens the services they need exactly when they need them."

"We've designed the system so cities such as Akron can automate their responses to citizen requests and collect important data that can be used to better manage city resources," said Rich Polulak, Motorola Communications and Electronics vice president and director, Integrated Solutions Division. "The CSR system enables the city to get a bird's eye view of its workflow management and make changes that will better serve its citizens."

Akron had used a manual system to route citizen requests. When a call came in, the request was entered, an order was printed, and then manually delivered to the appropriate department for resolution.

"Only our public-safety and sewer and water departments were able to respond to citizen requests within 24 hours," said Marco Sommerville, president of the Akron city council. "In addition, there was no way to track the requests we received because complaint taking and record keeping was spread over various departments that were unable to share data."

In future phases, citizens will be able to submit requests over the Internet and then the CSR system will wirelessly transmit those requests instantly to inspectors out in the field and other work crews. Citizens will then be provided with a service request number and an anticipated response time. As an extra check, if deadlines for certain tasks are not met, the CSR system will automatically remind personnel assigned to those tasks that action is needed.

The system's first phase will be installed in the city's Public Service, Public Works, Recreations, Customer Services, and Sanitation departments, as well as the Mayor and Council's offices because they receive the majority of citizens' requests for assistance. In fact, on an average Monday, City Hall alone receives 12,000 calls for emergency and non-emergency requests. By the end of next year, the system will be rolled out to the rest of the city departments—a total of 2100 employees.

Other locales that use the Motorola CSR system for non-emergency requests include Baltimore, MD; Chicago, IL; San Jose, CA; and the Texas cities of Dallas, Austin, and Houston. Implementation of the system has begun in Winston-Salem, NC.

Two Firms Sign North American Distribution Agreement

SAN JOSE, CA—Bell Microproducts, a value-added distributor of semiconductor and computer-storage products, has signed an agreement with Intel Corp. to distribute select products in the US and Canada. Through this agreement, Bell Microproducts has added a wide array of Intel technology products to its comprehensive base of industrial and enterprise component offerings.

The agreement covers a wide variety of Intel products. Bell Microproducts will be franchised to carry the Intel Server Board family of single, dual, and quad motherboards, including the chassis, Xeon, Itanium, and Pentium 4 server microprocessors that support them. Bell Microproducts is also franchised for Intel connectivity products, including the complete line of Intel Pro 1000 and 100 adapters for Ethernet, iSCSi, and RAID. The agreement also includes the full line of Intel's Compact-PCI family.

Bell Microproducts provides added services through its four solution centers, including asset tagging, bar-coding, bracketing, custom labeling, destroking, device-testing firmware download, mode page changes, operation system load, and software duplication.

Bell Microproducts has joined the Intel Technology Provider Program, thus allowing small service providers and enterprise customers to resource Intel's products and support services.

Power Amplifier Is Selected For Bluetooth Products

OTTAWA, ONTARIO, CANADA—SiGe Semiconductor has announced that the RangeCharger™ PA2423L has been selected by Uniwill Computer Corp. for its Class 1 Bluetooth™ products. The device has been integrated into Uniwill's BTM2022-1-Y module, which is widely implemented into consumer products such as the B191H1 USB dongle, B190N1 access point (AP), and a series of notebook personal computers (PCs).

Uniwill is among the growing list of equipment manufacturers to select the PA2423L for Class 1 Bluetooth products. The PA2423L is a small form-factor variant of SiGe's PA2423 family of RangeCharger power amplifiers (PAs).

SiGe Semiconductor is the leading supplier of PAs for the Class 1 Bluetooth market—with about 55 percent of the market share in 2001, according to In-Stat/MDR. Since the lead device launched in June 2000, more than a million RangeCharger PAs have shipped, many of which can be found in certified Bluetooth Class 1 products currently on the market.

"I am delighted with our leadership position in the Bluetooth market, as it underscores our ability to identify opportunities, and quickly mobilize to bring solutions to market that meet OEM requirements," said Bill Cuming, vice president for optical, cable, and components at SiGe Semiconductor. "Uniwill's implementation of the PA2423L adds to our track record in delivering solutions that drive higher performance and reliability into the hands of consumers."

"I am delighted with our leadership position in the Bluetooth market."

Kudos

RESEARCH TRIANGLE PARK, NC—Unitive, Inc. announced that it has been named a Rising Star on Deloitte & Touche's 2002 North Carolina Technology Fast 50 list, a ranking of the 50 fastest-growing technology companies in the state. Rankings for the Rising Star are based on the percentage of growth in revenues from 1999 to 2001.

Unitive's 55-percent increase in revenues from 1999 to 2001 resulted in it being named a Rising Star in the 2002 North Carolina Technology Fast 50 winner.

Among the requirements to qualify as a Rising Star in the Technology Fast 50, companies must be public or private, headquartered in North Carolina, and be "technology companies" defined as companies that own proprietary technology which contributes to a significant portion of the company's operating revenues or devotes a high percentage of effort to the research and development (R&D) of technology.

ORLAND PARK, IL—Andrew Corp. has received E-2 Intelsat® type approval (Intelsat Approved Code IA099A00) for the two-port Ku-band version of its 4.9-m earth station antenna. The approval covers the antenna and its feed system. Andrew 4.9-m Ku-band earth station antennas can be used in multinational private networks, broadcast news reporting, and public-switched services.

EWING, NJ—Discovery Semiconductors, Inc. (DSC) has been named for the third consecutive year to Deloitte & Touche's "Technology Fast 50" Program for New Jersey, a ranking of the 50 fastest-growing technology companies in the area. Rankings are based on the percentage of growth in fiscal-year revenues from 1997 to 2001 (five-year period).

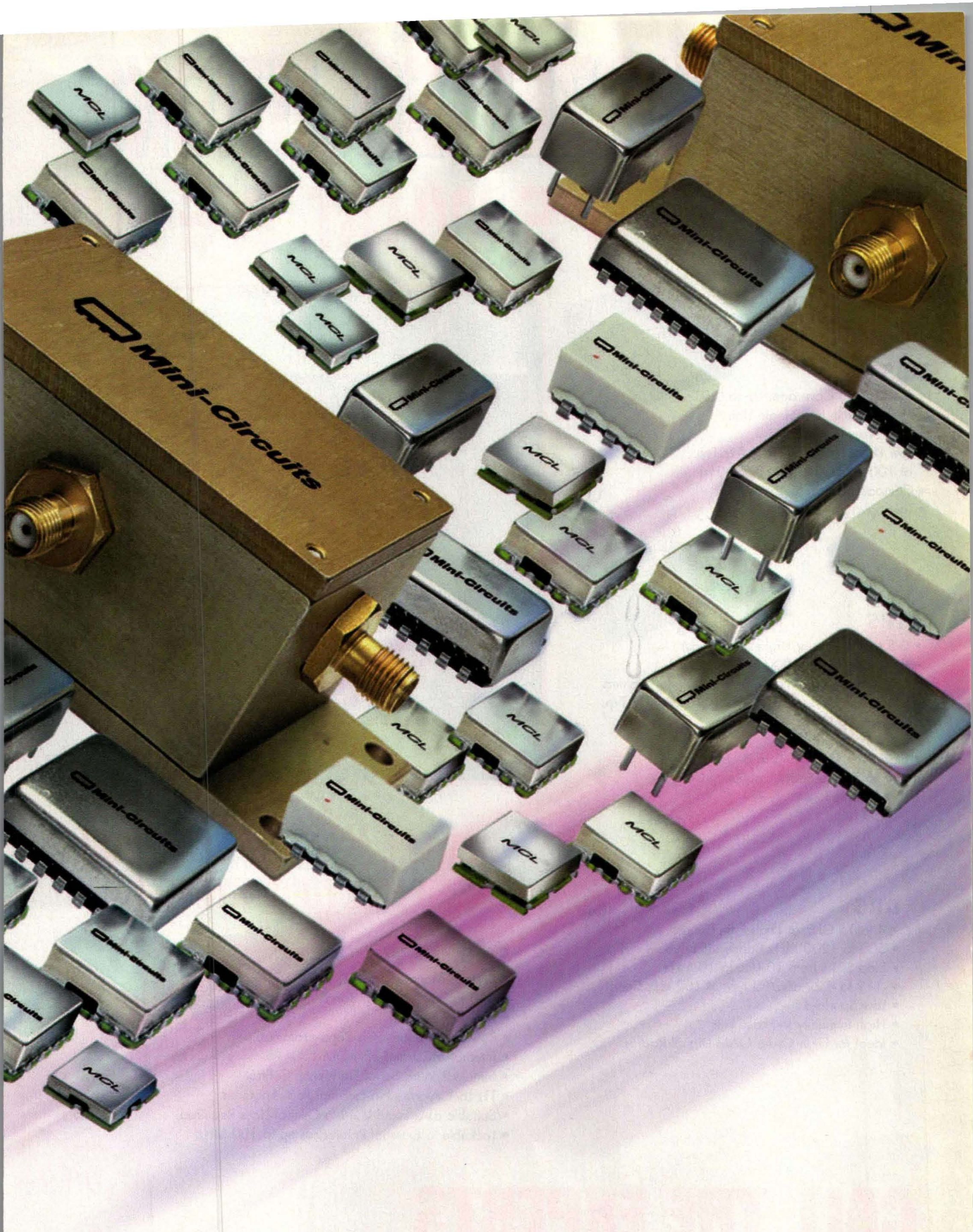
Discovery's increase in revenues of 591 percent from 1997 to 2001 resulted in a 33rd ranking overall in the Fast 50 for New Jersey.

Winners of the 20 regional Technology Fast 50 programs in the US and Canada are automatically entered in the Deloitte & Touche Technology Fast 500 program, which ranks North America's top 500 fastest-growing technology companies.

SAN DIEGO, CA—Zyray Wireless, a start-up company developing the SPINNER family of wireless semiconductor products based on Space-Time Processing technology, has been ranked tenth on the list of "Top 50 Companies to Watch in 2002," compiled by writers and researchers from Reed Business Information (formerly Cahners Business Information).

The publication, which evaluated a broad range of companies in the electronics industry, has chosen the top fifty companies that are developing innovative and vital technologies and products.

The list, which includes such recognized industry names as Advanced Micro Devices, Intersil, Microsoft, and IBM, was published in the July issue of *Electronics Industry's Movers and Shakers of 2002*, a special magazine supplement that is produced annually by Reed Business Information. MRF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NEWS

2002 IEDM Explores Emerging Semiconductors

For RF and microwave applications, the quest for higher frequencies and higher power levels drives researchers to seek improvements in processes and device architectures.

JACK BROWNE
Publisher/Editor

Semiconductor technologies seem to race forward almost without impediment, especially in computer-related applications such as memory chips, logic, and processors. But those semiconductor processes geared for RF and microwave applications continue to advance steadily, even as the markets for these devices weaken, according to the latest set of presentations offered at the upcoming 2002 International Electron Devices Meeting (IEDM). Scheduled for December 8-11, 2002 at the Hilton San Francisco & Towers (San Francisco, CA), the conference features a host of quality presentations from around the world on emerging semiconductor processes of interest to RF and microwave designers, including silicon-germanium (SiGe), silicon-carbide (SiC), and gallium-nitride (GaN) device technologies.

SiGe first came to public attention approximately a decade ago at the IEDM, with announcements by Analog Devices (Norwood, MA, www.analog.com) and IBM Microelectronics (East Fishkill, NY, www.ibm.com) on high-speed data converters and other circuits fabricated with the process. Since that time, the IBM SiGe foundry has won more than dozens of believers (and customers) for its high-frequency SiGe process, which now boasts devices capable of transition frequencies (f_Ts) well in excess of 100 GHz.

This past May, IBM announced the shipment of its 100 millionth chip made with SiGe, produced at the company's Burlington, VT facility. The chip was delivered to test-equipment manufacturer Tektronix (Beaverton, OR, www.tektronix.com). This past summer, the company finalized the largest private-sector investment in New York State history with the completion of a $2.5 billion wafer-fabrication facility in East Fishkill, NY. Featuring 12-in. (300-mm) wafers using low-k dielectrics, copper (Cu) interconnects, and silicon-on-insulator (SOI)-based transistors, the facility is fully automated (requiring some 20,000 sensors to track wafers), but will also add approximately 1000 technical jobs to New York's Hudson Valley. The LINUX-based facility is managed by approximately 1700 microprocessors running at 1 GHz with about 600 TB of memory. An internally developed software program known as SiView controls the manufacturing operations. According to New York Governor George E. Pataki, "I've been to Silicon Valley. They don't have the trees we have. They have earthquakes and their lights go out. The Hudson Valley is a much better place to innovate and work."

In addition to IBM, companies deeply involved in the development of SiGe

materials and semiconductors include Maxim Integrated Products (Sunnyvale, CA; www.maxim-ic.com) and Atmel (San Jose; CA, www.atmel.com). Most recently, Intel Corp. (Santa Clara, CA; www.intel.com) announced plans to develop SiGe-based mixed-signal circuits which, combined with the company's expertise in complementary metal-oxide semiconductor (CMOS), would result in high-frequency devices for wireless local-area networks (WLANs), as well as high-speed circuits for optical components operating in excess of 50 Gb/s. Intel's Chairman, Andy Grove, will address IEDM attendees at a luncheon presentation entitled "Changing Vectors of Moore's Law."

Although SiGe is usually associated with lower-power, lower-voltage applications, several companies have explored the use of the semiconductor material for power amplifiers (PAs) and devices. The WPTB48F2729C SiGe power heterojunction bipolar transistor (HBT) from Northrop Grumman Electronic Systems' Advanced Technology Center (Baltimore, MD; www.northrop-grumman.com/es/atc) is designed for pulsed radar applications from 2.7 to 2.9 GHz. Suitable for air-traffic-control (ATC) systems, the transistor is rated for maximum collector voltage of +55 VDC and peak collector current of 14 A. It is configured for common-base operation and will deliver 180-W Class C output power (with 32-W input power) when tested with 60-μs pulses at a 6-percent duty cycle at 2.8 GHz.

SiGe Semiconductor (Ottawa, Ontario, Canada; www.sige.com) also recently unveiled a SiGe PA integrated circuit (IC), the SE2522L, targeted at WLAN amplification. Capable of operating at 100-percent duty cycle, the amplifier delivers +20-dBm linear output power at 2.4 GHz with adjacent-channel power ratio (ACPR) of less than –20 dBm per 100 kHz. Unlike the high-voltage Northrop Grumman device, the SE2522L is designed for a supply voltage of +3.3 VDC.

Several presentations at the IEDM will highlight research advances in SiGe, including a report by J. Bock and associates from Infineon Technologies (Munich, Germany; www.infineon.com) revealing devices with gate delays of less than 5 ps. Designed for mixed digital and analog use, the SiGe bipolar technology achieves f_T of 155 GHz at a breakdown voltage of +1.9 VDC, and a maximum frequency of oscillation (f_{max}) of 167 GHz with only 4.7-ps gate delay. The researchers will detail a 99-GHz digital frequency divider and a low-noise amplifier (LNA) with 2.2-dB noise figure at 19 GHz.

At even higher frequencies, researchers at IBM Microelectronics will announce a new SiGe process featuring a raised extrinsic base with low base resistance

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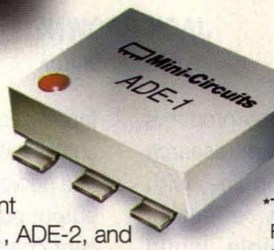

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*Typical Specifications:	ADE-1	ADE-2	ADE-11X
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Frequency LO/IF (MHz)	DC-500	DC-1000	5-1000
LO Level (dBm)	7	7	7
IP3 (dBm)	15	20	9
Conv. Loss (dB)	5.0	6.67	7.1
L-R Isolation (dB)	55	47	36
L-I Isolation (dB)	40	45	37
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(for low noise and high gain). The novel architecture allows the process to achieve HBT devices with f_T performance of 200 GHz and f_{max} performance of 285 GHz. The fabricated devices feature emitter stripe width of 0.12 µm with stripe length optimized to balance high perimeter-to-area ratio (and achieve the low base resistance). The technology implies useful LNAs to 26 GHz, with the researchers to report minimum noise figures of 0.4 and 1.5 dB, respectively, at 10 and 26 GHz. And if 200 GHz is not high enough, J.S. Rich and additional IBM researchers will also report on SiGe HBTs with cutoff frequencies approaching 300 GHz.

D. Knoll and associates from IHP (Frankfurt, Germany) will reveal their efforts at creating a simplified, low-cost SiGe:C bipolar-CMOS (BiCMOS) process capable of producing a one-mask HBT module. The technology is a 0.25-µm BiCMOS SiGe:C process with 19 lithographic steps offering four levels of aluminum (Al) and a variety of active and passive devices. Based on a standard CMOS approach, the process can be used to fabricate devices with f_T performance to 75 GHz at +2.4 VDC. Takashi Hashimoto and associates from Hitachi Ltd. (Tokyo, Japan) will also unveil their work on the integration of a standard CMOS process platform with 0.13-µm SiGe. The approach yields HBT devices with cutoff frequency of 122 GHz and f_{max} of 178 GHz due to the low base resistance.

In the area of power-device technology, James Fiorenza and fellow researchers from the Massachusetts Institute of Technology (Cambridge, MA) will review new technology for RF-power laterally-diffused-metal-oxide-semiconductor (LDMOS) transistors above 2 GHz. The novel approach features a damascene gate with very low gate resistance to minimize RF gate-resistance losses. Using this topology, the researchers examined three approaches for reducing RF substrate losses: SOI technology, high-resistivity-bulk-silicon (HRS) technology, and high-resistivity SOI technology. The HRS technology was found to improve power-added efficiency (PAE) compared to standard bulk Si. By combining the low-loss substrates with metal/poly-Si damascene gates with low sheet resistance, the researchers created LDMOS devices with 0.5-µm gate length and 20-nm gate-oxide thickness on high-resistivity SOI substrates capable of +23-dBm output power at 1.9 GHz and +3.6 VDC and +27-dBm output power at 1.9 GHz and +6 VDC. The peak PAEs are 60 and 63 percent, respectively, with PAE of nearly 45 percent possible at 4 GHz.

SiC has long been a substrate of interest for high-power-device developers. Cree Microwave (Sunnyvale, CA), for example, recently announced its new LDMOS 8 process technology based on SiC. At present 30- and 60-W transistors have been released to production, with larger 85- and 125-W devices soon to follow. The devices are

Tracking New Semiconductor Products

JACK BROWNE
Publisher/Editor

Research sparks the imagination, but new products pay the bills. In some cases, semiconductor research requires years to reach the production line, with many current new-product developments reflecting research of several years ago. For example, while researchers from Texas Instruments will reveal the results of work on a 0.1-µm complementary-metal-oxide-semiconductor (CMOS) process, engineers at AMI Semiconductor (Pocatello, ID) have employed a 0.35-µm CMOS process to create an RF transceiver chip aimed at the low-power (Zigbee) 802.15.4 specifications. The device integrates an RF transmitter (Tx) and receiver (Rx), as well as a baseband processor. The company's Astric transceiver operates below 1 GHz at 40 kb/s at distances to 100 m using direct-sequence spread spectrum (DSSS) over the 868-to-928-MHz band for applications in medical diagnostic equipment, keyless entry systems, and agricultural equipment.

Similarly, Powerfore, a subsidiary of Tavanza, Inc. (Sunnyvale, CA; powerfore.com), recently introduced the WL2425 wireless-local-area-network (WLAN) power amplifier (PA), fabricated in 0.25-µm RF CMOS. The integrated circuit (IC) consists of three amplifier stages, an input-matching circuit, and power-management circuitry. It delivers +20-dBm linear output power (and 28-dB power gain) at 2.4 GHz with adjacent-channel power ratio (ACPR) of –32 dBc for the first sidelobe and –55 dBc for the second sidelobe. The amplifier operates on a single voltage supply of +2.7 to +3.3 VDC.

Marvell Technology (Sunnyvale, CA; www.marvell.com) has also turned entirely to CMOS for its two WLAN chip sets, one for access points (APs) and one for clients, using the 88W8000 RF transceiver and the 88W8300 baseband/media-access controller (MAC) for clients and the 88W8000 with the 88W8500 10/100 Ethernet/MAC controller for APs. The transceiver has an on-board PA that delivers output-power levels of 0 to +20 dBm in 1-dB steps. The Rx has sensitivity of –88 dBm without using external components. Both processors include clear-channel-assessment (CCA) capability to detect interference and determine how to combat it. The chip sets also include AES encryption capabilities.

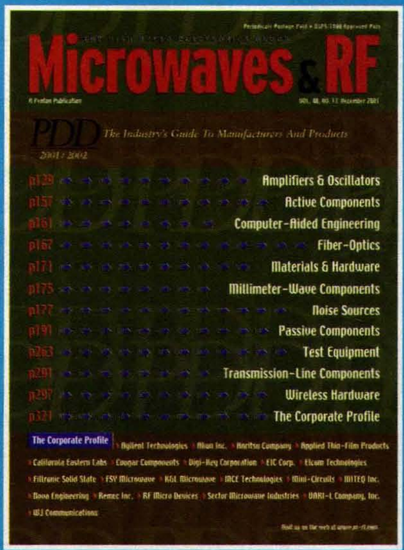
designed for cellular and personal-communications-services (PCS) frequency ranges for use in cell sites and base-station equipment.

Pushing the high-frequency limits of SiC by combining it with GaN technology, R. Quay and associates from the Fraunhofer-Institute of Applied Solid-State Physics (Freiburg, Germany) will describe their work on devices intended for frequencies through 40 GHz. They will describe AlGaN/GaN high-electron-mobility transistors (HEMTs) fabricated on SiC substrates capable of breakdown voltages up to +60 VDC. For devices suitable for high-power use (with extended gate-drain spacing), the researchers achieved cutoff frequencies to 60 GHz and f_{max} up to 140 GHz at a drain-source voltage of +7 VDC, the highest reported frequencies for GaN-based HEMTs.

H. Kashahara and associates from the Photonic and Wireless Devices Research Labs of NEC Corp. (Shiga, Japan) will also detail their experiences with power GaN devices, notably at Ka-band frequencies. The researchers work on power AlGaN/GaN heterojunction field-effect transistors (FETs) has yielded more than 2-W output power at 30 GHz from a single chip with a gate width of 0.36 mm. By developing a device with a gate length of 0.25 µm, the researchers achieved linear gain of 8.8 dB at 30 GHz and 6.6 dB at 38 GHz, indicating the potential of this technology for millimeter-wave use.

Using gallium indium phosphide/gallium arsenide (GaInP/GaAs), researchers from the Ferdinand-Braun Institut fur Hochstfrequenztechnik (Berlin, Germany) and United Monolithic Semiconductors GmbH (Ulm, Germany) will offer HBT power cells operating to +32 VDC as an alternative to high-voltage Si LDMOS transistors. The power cells are capable of delivering 10 W of output power at 2 GHz with considerably higher output impedances than silicon LDMOS devices, making it significantly easier to combine the outputs of multiple devices in high-power applications.

Finally, lest CMOS be forgotten **(see sidebar)**, J.Y. Yang and co-workers from Texas Instruments (Dallas, TX) will report at IEDM on a 0.1-µm RF CMOS process on high-resistivity substrates for system-on-chip (SoC) applications. The researchers will offer results for devices past 5 GHz, using a standard process approach that allows the use of standard library device models and structures. For more information about the 2002 IEDM, please contact Phyllis Mahoney, Conference Manager, Widerkehr & Associates, 16220 S. Frederick Ave., Suite 312, Gaithersburg, MD 20877; (301) 527-0900, or visit the IEDM website at www.ieee.org/conference/iedm. MRF



Ultra-Low Noise AMPLIFIERS VHF To V-BAND

MODEL NUMBER	FREQUENCY RANGE (GHz)	GAIN (dB, Min.)	GAIN VARIATION (±dB, Max.)	NOISE FIGURE (dB, Max.)	VSWR IN	VSWR OUT	POWER OUT @ 1 dB COMP. (dBm, Min.)	DC POWER @ +15 V (mA, Nom.)
OCTAVE BAND AMPLIFIERS								
JS2-00500100-045-5A	0.5 – 1	35	1	0.45	2:1	2:1	5	250
JS2-00500100-12-5A	0.5 – 1	35	1.2	1	2:1	2:1	5	250
JS2-01000200-045-5A	1 – 2	33	1	0.45	2:1	2:1	5	250
JS2-02000400-045-5A	2 – 4	28	1.2	0.45	2:1	2:1	5	175
JS2-04000800-08-0A	4 – 8	22	1.2	0.8	2:1	2:1	0	150
JS3-04000800-08-5A	4 – 8	30	1	0.8	2:1	2:1	5	175
JS3-04000800-15-5A	4 – 8	30	1	1.5	2:1	2:1	5	175
JS2-08001200-11-5A	8 – 12	15	1	1.1	2:1	2:1	5	150
JS3-08001200-11-5A	8 – 12	25	1	1.1	2:1	2:1	5	175
JS3-08001200-15-5A	8 – 12	25	1	1.5	2:1	2:1	5	175
JS3-12001800-16-5A	12 – 18	23	1	1.6	2:1	2:1	5	175
JS4-12001800-145-5A	12 – 18	30	1	1.45	2:1	2:1	5	200
JS4-12001800-30-5A	12 – 18	30	1	3	2:1	2:1	5	200
JS2-18002600-20-5A	18 – 26	14	2	2	2.5:1	2.5:1	5	100
JS2-18002600-30-5A	18 – 26	14	2	3	2.5:1	2.5:1	5	100
JS3-18002600-20-5A	18 – 26	22	1.8	2	2.5:1	2.5:1	5	175
JS3-18002600-30-5A	18 – 26	22	1.8	3	2.5:1	2.5:1	5	175
JS4-18002600-19-5A	18 – 26	33	1.5	1.9	2:1	2:1	5	200
JS4-18002600-26-5A	18 – 26	33	1.5	2.6	2:1	2:1	5	200
JS2-26004000-35-5A	26 – 40	10	2	3.5	2.5:1	2.5:1	5	100
JS2-26004000-45-5A	26 – 40	10	2	4.5	2.5:1	2.5:1	5	100
JS3-26004000-35-5A	26 – 40	18	2.5	3.5	2.5:1	2.5:1	5	175
JS3-26004000-45-5A	26 – 40	18	2.5	4.5	2.5:1	2.5:1	5	175
JS4-26004000-40-5A	26 – 40	23	2.5	4	2:1	2:1	5	200
JS4-40006000-65-0A	40 – 60	15	3	6.5	2.75:1	2.75:1	0	175
MULTIOCTAVE BAND AMPLIFIERS								
JS2-00500200-07-5A	0.5 – 2	32	1	0.7	2:1	2:1	5	295
JS2-00500200-15-5A	0.5 – 2	32	1	1.5	2:1	2:1	5	295
JS2-01000400-08-5A	1 – 4	27	1	0.8	2:1	2:1	5	200
JS2-01000400-20-5A	1 – 4	27	1	2	2:1	2:1	5	200
JS2-02000600-08-5A	2 – 6	22	1	0.8	2:1	2:1	5	125
JS2-02000600-20-5A	2 – 6	22	1	2	2:1	2:1	5	125
JS2-02000800-08-0A	2 – 8	22	1.25	0.8	2:1	2:1	0	125
JS2-02000800-20-0A	2 – 8	18	1.25	2	2:1	2:1	0	125
JS3-02001800-25-5A	2 – 18	23	1.8	2.5	2.5:1	2.5:1	5	150
JS3-02001800-50-5A	2 – 18	23	1.8	5	2.5:1	2.5:1	5	150
JS4-02001800-22-5A	2 – 18	30	2	2.2	2.5:1	2.5:1	5	200
JS4-02001800-50-5A	2 – 18	30	2	5	2.5:1	2.5:1	5	200
JS3-02002600-33-5A	2 – 26	21	2.5	3.3	2.5:1	2.5:1	5	150
JS3-02002600-40-5A	2 – 26	21	2.5	4	2.5:1	2.5:1	5	150
JS3-06001800-16-5A	6 – 18	23	1.8	1.6	2:1	2:1	5	125
JS3-06001800-30-5A	6 – 18	23	1.8	3	2:1	2:1	5	125
JS4-06001800-145-5A	6 – 18	31	2	1.45	2:1	2:1	5	200
JS4-06001800-30-5A	6 – 18	31	2	3	2:1	2:1	5	200

Amplifier Features Low +12-VDC Operation

MODEL ISG52124-L IS a silicon (Si) return-path hybrid amplifier module that features a 5-to-210-MHz bandwidth range and low +12-VDC operation. The unit provides a digital, drop-in, data-ready solution for high-density cable-television (CATV) systems. Gain is 24 dB typical and gain flatness is ±0.4 dB maximum. Return loss is 18 dB typical and operating current is less than 100 mA typical. CTB is –63 dBc typical, XM is –56 dBc typical, and CSO is –66 dBc typical. Designed for upstream amplification in optical networks, the ISG52124-L can be easily matched with optical components. The unit is housed in an industry-standard SOT-115 package and is assembled on automated production lines to ensure consistent, uniform performance. The surface-mount components provide reliability in adverse environmental and mechanical conditions. P&A: $12.00 ea. (10,000 qty.).

ISG Broadband, Inc., 1567 Centre Pointe Dr., Milpitas, CA 95035; (408) 957-8000, FAX: (408) 957-8008, Internet: www.isgbroadband.com.

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Stub Protector Spans 820 To 970 MHz

Model QSS 7F7M AD 00 is a narrowband 7-16 female bulkhead to 7-16 male quarter-wave stub protector that features no protruding stub for high-density packaging. Frequency range is from 820 to 970 MHz and RF power is 3 kW root mean square (RMS)/25 kW peak. Return loss is –32.2 dB typical to –26.4 dB minimum and VSWR is 1.05:1 typical to 1.1:1 maximum. Insertion loss is 0.05 dB typical to 0.1 dB maximum. Third-order PIM is greater than –150 dBc.

NexTek, Inc., 439 Littleton Rd., P.O. Box 385, Westford, MA 01886; (978) 486-0582, FAX: (978) 486-0583, Internet: www.nextechlightning.com.

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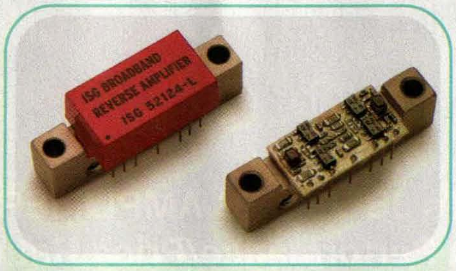
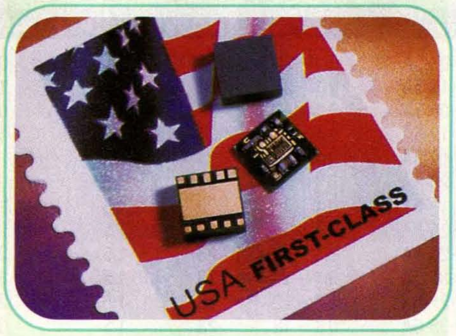
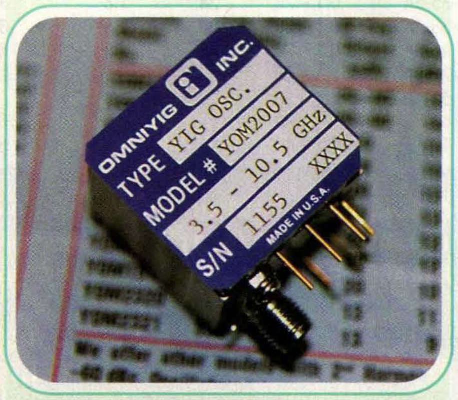


ISG BROADBAND MODEL ISG52124-L

NEXTEK, INC. MODEL QSS 7F7M AD 00



CELERITEK MODEL CHP0205-QM



OMNIYIG, INC. MODEL YOM2007

PA Targets cdma2000 3G Cellular Handsets

MODEL CHP0205-QM IS a linear power-amplifier (PA) module designed for transmit functions in cdma2000 third-generation (3G) cellular multimode data-enabled handset applications. The PA operates from 824 to 849 MHz and offers 36-percent linear power-added efficiency (PAE), +28-dBm output power, lower RF power-efficiency enhancement, 50-Ω internal-matching and on-board DC power-down mode. The unit is housed in a 4.0 × 4.0 × 1.5-mm power module with minimal external circuitry for bias and matching. The PA is produced using indium-gallium-phosphide (InGaP) heterojunction-bipolar-transistor (HBT) technology.

Celeritek, 3236 Scott Blvd., Santa Clara, CA 95054; (408) 986-5060, FAX: (408) 986-5095, Internet: www.celeritek.com.

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YIG Runs 3.5 To 10.5 GHz

MODEL YOM2007 IS a multi-octave bipolar yttrium-iron-garnett (YIG) oscillator covering the 3.5-to-10.5-GHz frequency range. RF power output is +15 dBm minimum with a frequency-modulated (FM) noise of –120 dBc at 100 kHz away. Operating temperature is from –54 to +85°C. The unit is stable over the frequency range inclusive the drift and linearity by ±10 MHz typical, guaranteed ±12 MHz. The unit can be integrated with an analog driver with up to +10-VDC control or a 12-b digital driver to tune the full frequency range. FM coil sensitivity is 240 to 400 kHz/mA, FM coil inductance is 1 MHz, FM coil resistance is 1 Ω, FM coil rate is 200 kHz, and FM coil deviation is ±10 MHz. Tuning linearity is ±14 MHz and tuning speed is 8 ms.

OMNIYIG, Inc., 3350 Scott Blvd., Bldg. No. 66, Santa Clara, CA 95054-3125; (408) 988-0803, FAX: (408) 727-1373, e-mail: omniyig@ix.netcom.com, Internet: www.omniyig.com.

● **Enter No. 62 at www.mwrf.com**

Firms Enter Into Partnership

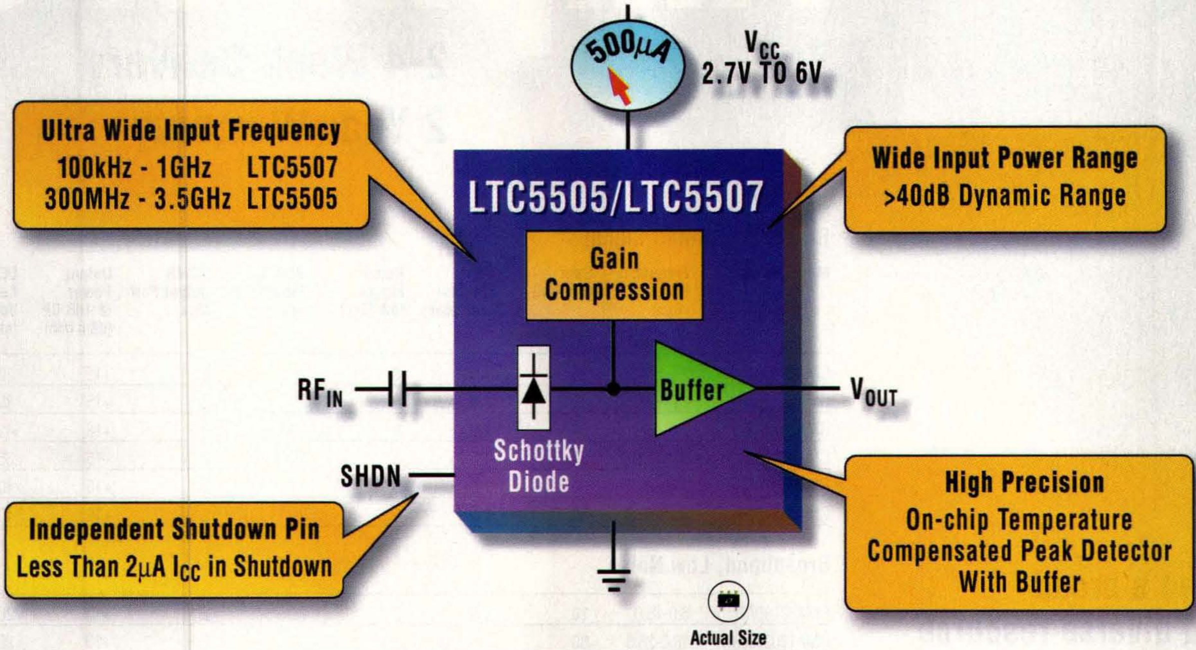
SPIRENT PLC, AN INTERNATIONAL network technology company, and UbiNetics, a developer of licensable core technologies and test equipment for third-generation (3G) wireless voice and data applications, have entered into a strategic partnership to expand their test solutions for the 3G market.

Under the terms of the agreement, Spirent has acquired UbiNetics' CS100 product line and rights to associated intellectual property for 6.5 million UK pounds in cash (approximately $10.06 million US). In addition, under the agreement Spirent and UbiNetics will partner for the further development of the CS100 product line and future test platforms. The CS100 3G base-station emulator product is used by leading mobile-phone manufacturers and chip-set developers for the test and verification of wideband-code-division-multiple-access (WCDMA) user equipment and provides a flexible multicell simulation of the physical layer of a WCDMA network.

The partnership brings strategic benefits to both parties. Spirent's Communications group has already developed a strong global presence with its test solutions for 3G wireless networks based on CDMA technology and this relationship will extend Spirent's expertise into WCDMA air-interface testing. UbiNetics is a market leader in the development of WCDMA Test Mobiles and will benefit from the application of Spirent's data-generation and analysis capabilities, as well as its expertise in the integration of complex wireless test solutions. As a result of the partnership, both parties will be able to develop complementary advanced solutions for testing and managing complex WCDMA infrastructure and user equipment.

Commenting on the partnership, Geoff Zeidler, president of Spirent Communications—Europe and Wireless, said, "Wideband CDMA technology will enable the deployment of new wireless services in the majority of the world's markets. I am delighted that this partnership with UbiNetics will enable Spirent to extend its reputation for delivering market-leading solutions to meet the demanding development requirements of its wireless customers." MRF

RF Power Detectors
Low Power – Wide Range



RF In → Baseband Out With One or Two External Components

The LTC®5505 and LTC5507 are 100% production tested at frequency to minimize calibration and rework of the end device. The 1mm ThinSOT™ package provides reliability, low thermal resistance, simple solder joint visual inspection and requires no special handling. With 500μA supply current and minimal number of external components, the easy-to-use LTC5505 and LTC5507 offer the industry's lowest power and smallest total solutions. Applications include: Mobile Phones, Wireless and Cable Infrastructure, Wireless Data Modems, ASK Demodulators, Optical Power Detectors, Envelope Detectors.

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LT5503	1.2GHz to 2.7GHz Direct IQ Modulator and Mixer
LT5500	1.8GHz to 2.5GHz RF Receiver Front End
Infrastructure and Handset	
LT5504	800MHz to 2.7GHz RF Measuring Receiver with 80dB Dynamic Range
LT5511	High Signal Level Upconverting Mixer with +17dBm Input IP3
LT5512	High Signal Level Downconverting Mixer with +17dBm Input IP3
LTC4400	RF Power Controllers with Autozero Loop for GSM/GPRS Cellular Phones
LTC4401	RF Power Controllers with Autozero Loop for GSM/GPRS Cellular Phones

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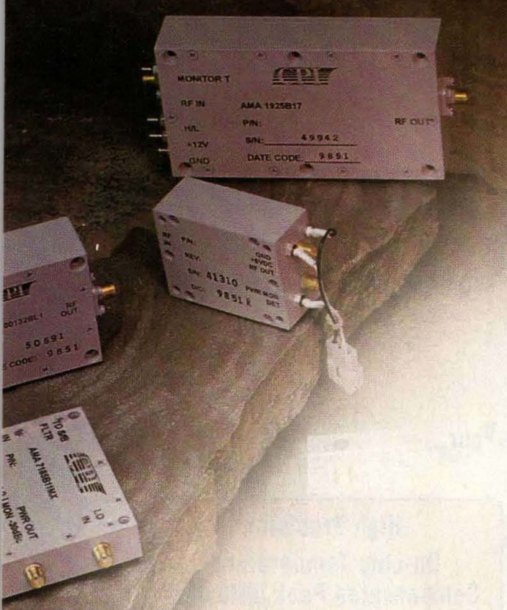

Broadband, Small Signal

Model Number	Frequency Range (Ghz)	Gain (dB Min)	Gain Flatness (±dB Max)	Noise Figure (dB Max)	VSWR Input Port Max	VSWR Output Port Max	Output Power @ 1dB CP (dBm Min)	DC Input Current Vdc:+12 (mA Typ)
CMA2080A1	2.0-8.0	30	1.5	6	2:1	2:1	+15	200
CMA20120A	2.0-12.0	33	2.0	6	2:1	2:1	+15	350
CMA20180A	2.0-18.0	34	2.0	6	2:1	2:1	+18	450
CMA60180A1	6.0-18.0	36	1.5	6	2:1	2:1	+15	350
CMA180265A	18.0-26.5	30	1.5	6	2:1	2:1	+16	400
CMA265400A	26.5-40.0	30	1.5	6	2:1	2:1	+16	400

Broadband, Low Noise

Model Number	Frequency Range (Ghz)	Gain (dB Min)	Gain Flatness (±dB Max)	Noise Figure (dB Max)	VSWR Input Port Max	VSWR Output Port Max	Output Power @ 1dB CP (dBm Min)	DC Input Current Vdc:+12 (mA Typ)
CMA60180A2	6.0-18.0	30	1.5	3	2:1	2:1	+10	200
CMA180265A1	18.0-26.5	30	1	3	2:1	2:1	+10	200
CMA265400A1	26.5-40.0	28	1.5	3.5	2:1	2:1	+10	200

Medium Power

Model Number	Frequency Range (Ghz)	Gain (dB Min)	Gain Flatness (±dB Max)	Noise Figure (dB Max)	VSWR Input Port Max	VSWR Output Port Max	Output Power @ 1dB CP (dBm Min)	DC Input Current Vdc:+12 (mA Typ)
CMA5964B10	5.9-6.4	40	1.0	8	1.5:1	1.5:1	+33	1500
CMA5971B1	5.9-7.1	20	1.0	10	1.8:1	1.8:1	+33	1500
CMA7185B2	7.1-8.5	20	1.0	10	1.8:1	1.8:1	+33	1500
CMA85125B1	8.5-12.5	30	1.5	8	2:1	2:1	+35	3000
CMA107117B2	10.7-11.7	20	1.0	10	1.8:1	1.8:1	+33	2000
CMA127132B	12.7-13.2	40	1.0	5	1.8:1	1.8:1	+34	4000
CMA137145B	13.7-14.5	45	1.0	6	1.5:1	1.8:1	+33	1500
CMA142153B6	14.2-15.3	15	1.0	8	1.5:1	1.8:1	+30	1000
CMA177197B15	17.7-19.7	35	1.0	8	1.5:1	2:1	+30	1100
CMA181186B17	18.1-18.6	34	0.5	10	1.5:1	1.5:1	+33	3000
CMA200230B1	20.0-23.0	10	1.0	12	1.5:1	2:1	+30	1000
CMA295297B1	29.5-29.7	20	0.3	10	1.5:1	1.8:1	+30	1000

High Power

Model Number	Frequency Range (Ghz)	Gain (dB Min)	Gain Flatness (±dB Max)	Noise Figure (dB Max)	VSWR Input Port Max	VSWR Output Port Max	Output Power @ 1dB CP (dBm Min)	DC Input Current Vdc:+12 (mA Typ)
CMA1616B	1.6-1.68	45	0.25	10	2:1	2;1	+43	8500
CMA4450B27	4.4-5.0	40	1.0	8	1.5:1	1.5:1	+43	11000
CMA5964B40	5.9-6.4	40	1.0	8	1.5:1	1.5:1	+43	12000
CMA127132B7	12.7-13.2	40	1.0	8	1.5:1	1.5:1	+43	20000
CMA137145B19	13.7-14.5	53	1.0	6	1.5:1	1.5:1	+43	22000

TWT/KPA Drivers, Linearized Gain Control

Model Number	Frequency Range (Ghz)	Gain (dB Min)	Gain Flatness (±dB Max)	Noise Figure (dB Max) @ 0 Gain Control	VSWR In/Out Max	Gain Control (dB Max)	Output Power @ 1dB CP (dBm Min)	DC Input Current Vdc:+12 (mA Typ)
CMA5866A13	5.8-6.6	30	1.0	7	1.4:1/1.3:1	25	+13	260
CMA7984A1	7.9-8.4	30	1.0	7	1.4:1/1.3:1	25	+13	260
CMA127145A6	12.7-14.5	35	1.5	7	1.4:1/1.3:1	25	+18	500
CMA173184A8	17.3-18.4	38	1.0	7	1.4:1/1.3:1	25	+20	500
CMA270310A4W/G	27.0-31.0	20	1.0	10	1.5:1/2.0:1	25	+20	500

Note: Gain control voltage range is 0 to +10 Vdc (Maximum gain @ +10 Vdc)

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CONTRACTS

Rockwell Collins—Has been selected by Sikorsky Aircraft to provide displays for the US Army fleet of 1200 or more Sikorsky BLACK HAWK Uh-60M aircraft.

Rockwell Collins anticipates more than $225 million in sales from the contracts, when fully executed, over the 20-year life of the program. Rockwell Collins and Sikorsky have entered into a letter of intent for this program and are working to finalize definitive agreements.

PC Dynamics—Signed a $440,000 contract with Lockheed Martin NE&SS—Surface Systems to supply microwave-circuit components for its Aegis program. If all options are exercised and PC Dynamics meets all performance criteria, the contract's value would be approximately $3.1 million over the next five years.

This is the ninth consecutive year that PC Dynamics has been selected to supply a vital part of the Aegis program.

Vodafone Group plc—Announced that it has signed and completed an agreement for the acquisition of Vivendi's 50-percent stake in the Vizzavi Group companies that operate the joint-venture mobile-content business. As a result of this transaction, Vodafone owns 100 percent of Vizzavi, with the exception of Vizzavi France, which is now wholly owned by Vivendi Universal S.A.

Vivendi has received Euro 142.7 million (approximately $141.4 million US) in cash. Following the acquisition, Vizzavi has no further indebtedness outstanding to Vivendi.

Vodafone will continue to focus Vizzavi's operations on providing multimedia entertainment-led consumer content aimed at increasing customer usage and to further integrate these operations into the Vodafone Group.

FRESH STARTS

The Connecticut Microwave Corp. (CMC)—Acquired the combiner, duplexer, and filter product lines of Davicom Technoloigies, Inc. The acquisition included all engineering, tooling, manufacturing process data, and work in process.

These products are primarily used in dedicated systems including business (gas-line companies), safety (911), and municipal (police). They also complement the directional-coupler and circulator products manufactured by CMC since 1971 for frequency-modulation (FM) radio and television transmitter (Tx) manufacturers.

Ansoft Corp.—Dr. Zoltan J. Cendes, Ansoft's chairman and chief technology officer, spoke at SG Cowen Securities Corp.'s 30th annual Fall Technology Conference, which was held recently at the Sheraton Boston Hotel in Boston, MA.

Dr. Cendes' presentation outlined Ansoft's electronic-design-automation (EDA) tools and how the evolving technology provides Ansoft with substantial potential for growth, despite the recent economic recession in the technology sector.

Amcom Communications, Inc.—Appointed KJS Marketing to be the exclusive representatives for Illinois, Missouri, Minnesota, Kansas, Iowa, Nebraska, and Wisconsin.

KJS Marketing has offices in Maryland Heights, MO, Lakewood, IL, Lake Lotowana, MO, and Plymouth, MN. Amcom designs and manufactures gallium-arsenide field-effect-transistor (GaAs FET) power semiconductor devices and monolithic-microwave integrated circuits (MMICs).

Sprint—Announced that it has signed a multiyear agreement with the Detroit Lions of the National Football League to provide integrated voice and data communications solutions at Ford Field, the Lions' new home stadium, and at the Lions' new team headquarters and training facility located in Allen Park, MI.

The Lions will purchase long-distance voice services, Gigabit data services, and a wide range of communications equipment from Sprint. The Gigabit data services will network together Ford Field with the team's headquarters and training facility. Sprint is also providing services to retail centers throughout the Ford Field complex.

Antenova—Has secured 6 million UK pounds (approximately $9.4 million US) of second-round venture capital for its small and directional-antenna technology, from a consortium led by Quester and Cambridge Gateway Fund. Almost double the size of its first round in 2001, the new level of funding reflects the importance of Antenova's development work for mobile-phone and wireless original equipment manufacturers (OEMs).

SV Microwave—Has moved into a new 40,000-sq.-ft. state-of-the-art facility in West Palm Beach, FL. The facility is located adjacent to Palm Beach International Airport. The new facility includes manufacturing, assembly, inventory, research- and-development (R&D), quality-assurance, and administrative offices. SV Microwave is ISO 9001 certified.

Gabriel Electronics, Inc. and Zeus Electronics, Inc.—Have concluded negotiations that appoint Zeus as Gabriel's exclusive sales agent of Gabriel's line of antenna solutions to the Rocky Mountain region of the US.

Zeus is located in Phoenix, AZ and has satellite offices in Denver, CO, Albuquerque, NM, and Salt Lake City, UT.

KDF—Announced that the Electronic Systems business of the Raytheon Co. has ordered a 943NT in-line sputtering tool for use in its El Segundo, CA facility. Electronic Systems, which is involved in the development and deployment of key defense programs, will use the 943NT in the manufacture of its advanced technology products.

Hittite Microwave Corp.—Appointed two new sales representative firms to serve customers in India and Taiwan. Syratron Marketing Private Ltd., headquartered in Bangalore, will handle sales in India, while Bandtek International Co. Ltd. will cover the market in Taiwan. MRF

CABLE

BAE SYSTEMS Appoints Cable To VP/GM Position

BAE SYSTEMS Information & Electronic Warfare Systems (IEWS) has named LARRIE CABLE to the position of vice president/general manager of the Information Dominance Systems (IDS) business area. Cable joined BAE SYSTEMS in 2000.

Trompeter Electronics—RON DESILETS to Mil/Aero business development specialist; formerly worked in a contract capacity with Raytheon Electronic Systems.

Semflex—JERRY PARSONS to Eastern regional sales manager; formerly Eastern regional sales manager at Harbour Industries.

Barry Industries—ROB SINCLAIR to sales and marketing manager; formerly employed with Alpha Industries.

Rockwell Collins—KEN A. PETERMAN to vice president of business development for Government Systems; formerly director of communication systems marketing for Government Systems.

Palomar Technologies—WAI SENG CHEW to director of Palomar's Asian office; formerly general manager for Asia at Vision Inspection (VI) Technology.

The StarFabric Trade Association—BOB SULLIVAN to the board of directors; remains as vice president and corporate director of technology at Hybricon Corp.

SV Microwave—MIKE WISNER to vice president of sales and marketing; formerly vice president of sales and marketing for Huber + Suhner.

Newport Corp.—VINCENT CHIN to the position of applications engineer for MRSI Advanced Packaging products in the Asia Pacific region; formerly senior process engineer at Datacon Asia Pacific Pte.

3M—FRANK R. LITTLE to the position of executive director of research and development (R&D), corporate technology, and communications markets; formerly vice president and general manager for the Corning Compensation Products Division.

RF Micro Devices—DANIEL A. DILEO to the board of directors; formerly executive vice president of the optoelectronics group at Agere Systems.

GIL Technologies—WILLIAM SCHAMBACK to the position of Eastern regional sales manager; formerly employed as an account representative with Fujikura America, Inc.

Texas Instruments' TI-RFid Systems—MICHAEL KNEBELKAMP to strategic marketing manager; formerly strategic marketing manager for automotive.

Network Associates, Inc.—DAVID ROCHE to vice president of global audit services; previously was a partner at Deloitte & Touche and managed the Enterprise Risk Management team for the West Coast practice.

Business Telecom, Inc. (BTI)—MICHAEL P. SHAMBO to vice president of Carrier Services; formerly president of Optical Energy.

Optrex America, Inc.—DALE H. MAUNU to associate director for business development and procurement; formerly director of marketing for flat-panel display products at Mitsubishi Electric & Electronics USA, Inc.

MAUNU

GUZMAN

Celerity Digital Broadband Test—SUE GUZMAN to vice president of sales; formerly Western regional sales manager at Teradyne, Inc. MRF

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Detailed technical program at:
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GHz Interconnect Workshop
October 27-30 (Sedona, AZ)
Poco Diablo Resort
Program Chairman: David Light, VP and General Manager
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NIST/ARFTG Measurements Short Course
December 3-4 (Washington, DC)
The Madison Hotel
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Internet: www.arftg.org

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▸ MEETINGS

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For further information, contact:
J.J. Heath-Caldwell—Marketing Coordinator
Phone: 01962 761 565
e-mail: jj@gcd.co.uk
Internet: www.armms.org

PowerSystems World
October 29-31 (Rosemont, IL)
Stephens Convention Center
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Examine High-Speed Components Of A 40-Gb/s SiGe HBT Design

SILICON-GERMANIUM (SiGe) heterojunction-bipolar-transistor (HBT) technology recently lent itself to the production of devices with 120-GHz f_T. Products for 40-Gb/s applications fabricated from SiGe bipolar-complementary-metal-oxide-semiconductor (BiCMOS) technologies are now emerging in the marketplace. In a recent paper, the high-speed portions of the 40-Gb/s system are examined. Digital capability is demonstrated through a 4:1 multiplexer (MUX) and a 1:4 demultiplexer (DeMUX) running more than 50 Gb/s error free at a –3.3-VDC power supply. Analog elements, including a lumped limiting amplifier operating with a 35-GHz bandwidth, a transimpedance amplifier with 220-Ω gain and 49.1-GHz bandwidth, a 21.5-GHz voltage-controlled oscillator (VCO) with more than –100-dBc/Hz phase noise at 1-MHz offset, and a modulator driver which runs a voltage swing twice the BV_{CEO} of the high-speed SiGe HBT are assessed. See "40-Gb/s Circuits Built From a 20-GHz f_T SiGe Technology," *IEEE Journal Of Solid-State Circuits,* Vol. 37, No. 9, September 2002, pp. 1106-1114.

Learn Direct-Digital Synthesis Approaches For S-Band Output Frequencies

DIRECT-DIGITAL SYNTHESIZERS (DDSs) provide precise beam shaping and forming as advantages over conventional RF approaches. A recent paper examines design and process methods that enable the direct-digital synthesis of S-band output frequencies using current indium-phosphide (InP) double-heterojunction-bipolar-transistor (DHBT) technology with a cantilevered base layer and undercut collector. The DDS chip operates at 9.2 GHz and generates sine waves to 4.56 GHz. The chip exhibits state-of-the-art phase noise of –140 dBc at a frequency offset of 1 kHz and a clock frequency of 2.5 GHz. According to the authors, further improvements will be implemented in future-generation circuits that will support Ku-band frequency synthesis. See "Ultrahigh-Speed Direct Digital Synthesizer Using InP DHBT Technology," *IEEE Journal Of Solid-State Circuits,* Vol. 37, No. 9, September 2002, pp. 1115-1119.

Examine A UWB Propagation Channel

ULTRA-WIDEBAND (UWB) radio signals are described as those having fractional bandwidth of typically more than 0.25. These signals are generated by driving an antenna with short electrical pulses, so these radio systems are referred to as short-pulse or impulse systems. A recent paper by R. Jean-Marc Cramer, Robert A. Scholtz, and Moe Z. Win offers results of a UWB study where arrays of propagation measurements were made. The authors describe the propagation measurement technique and an approach to the spatial and temporal decomposition of a range of measurements into wavefronts impinging on the receiving array is provided. Based on a modification of the CLEAN algorithm, the approach provides estimates of time-of-arrival, angle-of-arrival, and waveform shape. The method is applied to 14 arrays of indoor propagation methods in an office or laboratory. Statistical descriptions of the results are offered, based on a clustering model for multipath effects. The parameters of these statistical models are compared to results obtained for narrowband signal propagation in the indoor environment. See "Evaluation of an Ultra-Wide-Band Propagation Channel," *IEEE Transactions On Antennas And Propagation,* Vol. 50, No. 5, May 2002, pp. 561-570.

Discover A Proposed Communications Antenna Mounted On A Helicopter

A COMMUNICATIONS ANTENNA for a helicopter would feature radiating elements on the blades of the main motor, with a rotary RF coupling between the antenna and the radio equipment in the fuselage. According to a recent paper by Ronald J. Pogorzelski, this antenna setup would be suitable for communication with distant ground stations and satellites. The elements would be constructed either as vertical electric dipoles on the rotor blades, as horizontal electric dipoles on the rotor blades, or as horizontal slots on the blades. The rotary coupling would consist of several noncontact rotary waveguide joints, while the stator in the coupling would feature a number of input/output (I/O) probes that is equal to the number of rotor blades. The stator I/O probes would be connected to a beam-forming network connected through a coaxial cable to the radio equipment in the fuselage. Since the probes are stationary, this mode would also remain stationary. See "Communication Antenna in a Helicopter Rotor," *NASA Tech Briefs,* Vol. 26, No. 6, June 2002, pp. 41-42.

DESIGN

Single Chip Realizes Direct-Conversion Rx

Direct-conversion Rxs offer advantages in simplicity compared to conventional superheterodyne approaches, although attention must be paid to some of the trade-offs.

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Direct conversion of RF signals to baseband has long been a goal of communications systems designers. The approach can eliminate expensive and bulky hardware, but at the cost of some trade-offs in performance. What follows is an examination of the trade-offs associated with designing a direct-conversion receiver (Rx) compared to a traditional superheterodyne architecture, as well as details on a new direct-conversion Rx integrated-circuit (IC) subsystem.

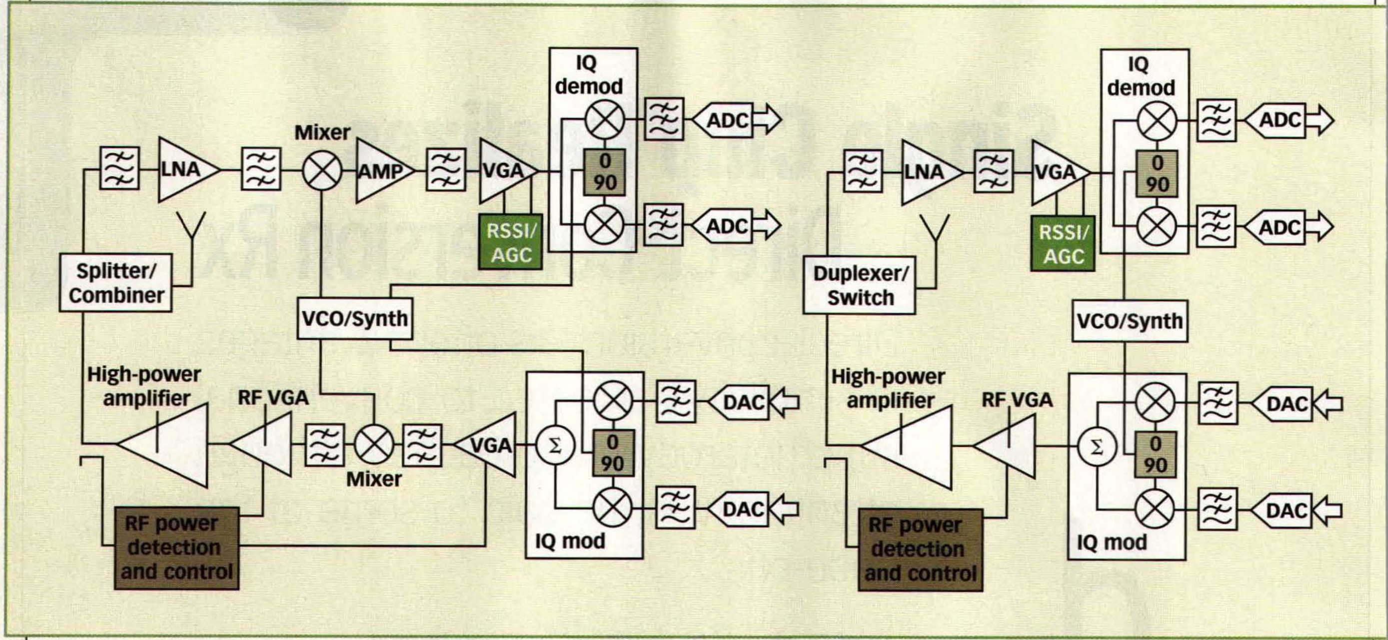
The function of a conventional superheterodyne Rx **(Fig. 1, left)** and a direct-conversion Rx **(Fig. 1, right)** is the same: translating and conditioning signals downward in frequency so that they can be sampled by low-frequency (baseband) analog-to-digital converters (ADCs). As is apparent from a comparison of the two block diagrams, the direct-conversion system achieves this function with considerably fewer components.

In a conventional single- or double-conversion superheterodyne Rx, the modulated RF signal is translated in frequency through one or more intermediate frequencies (IFs) before being converted back to its desired baseband format. At IF, the signal is filtered and amplified before being mixed to a lower frequency. In a direct-conversion Rx, the modulated RF signal is mixed with a local oscillator (LO) at exactly the same frequency.

The obvious reduction of component count, along with the elimination of expensive filtering has made direct conversion very appealing as an architecture for transmit and receive functions. However, it is only recently that components which facilitate its practical implementation have become available.

Although the direct-conversion approach reduces the component count, it also adds design challenges. In the superheterodyne approach (Fig. 1, left), by driving the mixer with a frequency-agile LO, the frequency of the desired signal or channel (which is generally varies in a multi-user system) is converted to a fixed frequency. Once the desired signal has been converted to a fixed IF, it can be processed by highly selective narrowband filtering using a surface-acoustic-wave (SAW) filter. In addition, all subsequent frequency translations can be effected using fixed-frequency LOs.

The other important function performed at IF in a superheterodyne system is signal amplification. Fixed-gain amplification, in the form of low-noise amplifiers (LNAs), is generally applied at RF, while signal leveling is general-



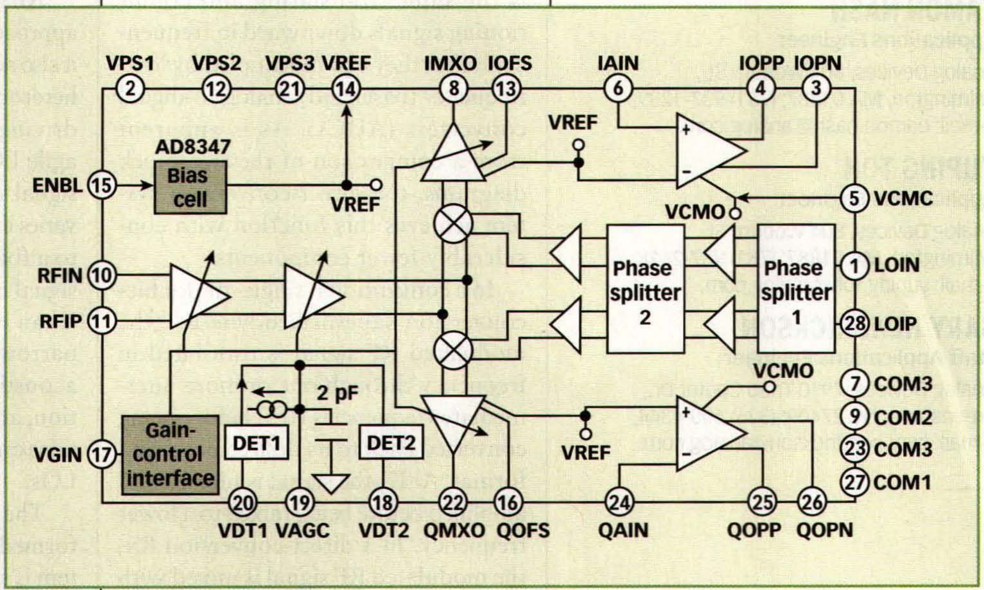
1. A conventional single-conversion superheterodyne Rx translates the frequency of desired signals through one or more IFs before converting it to baseband. A direct-conversion Rx makes the transition directly from RF to baseband.

ly accomplished through the use of variable-gain amplifiers (VGAs). Since it is easier to design a high-gain-range VGA at lower frequencies, and because many unwanted signal components have already been removed from the carrier by the time it is translated to IF, variable-gain amplification is generally performed at IF or baseband frequencies. This "distribution" of gain avoids a concentration of high gain at the Rx's front-end portion, which can cause saturation of subsequent stages, especially if large in-band or out-of-band signal blockers are present.

While the appeal of a direct-conversion Rx lies in its elimination of IF stages, therein lies its weakness. Because there is no longer an IF stage at which signal leveling and filtering can be conveniently performed, all signal conditioning must be performed either at RF or baseband. In a multichannel system, the capabilities of RF filters are limited (they cannot be narrowband), at best screening out-of-band interferers. SAW filters are available for some RF uses (through approximately 3 GHz), but they are generally more expensive than lower-frequency IF filters due to the higher quality-factor (Q) requirements.

A cost-effective means of realizing a direct-conversion Rx is through monolithic fabrication, by including as many of the required components on a single chip, such as the AD8347 direct-conversion Rx IC **(Fig. 2)** from Analog Devices (Norwood, MA). This Rx IC can demodulate signals from 0.8 to 2.7 GHz. The device consists of a number of subcircuits that can be configured separately. The IC includes all of the components required for amplification, downconversion, and filtering in a direct-conversion demodulation circuit.

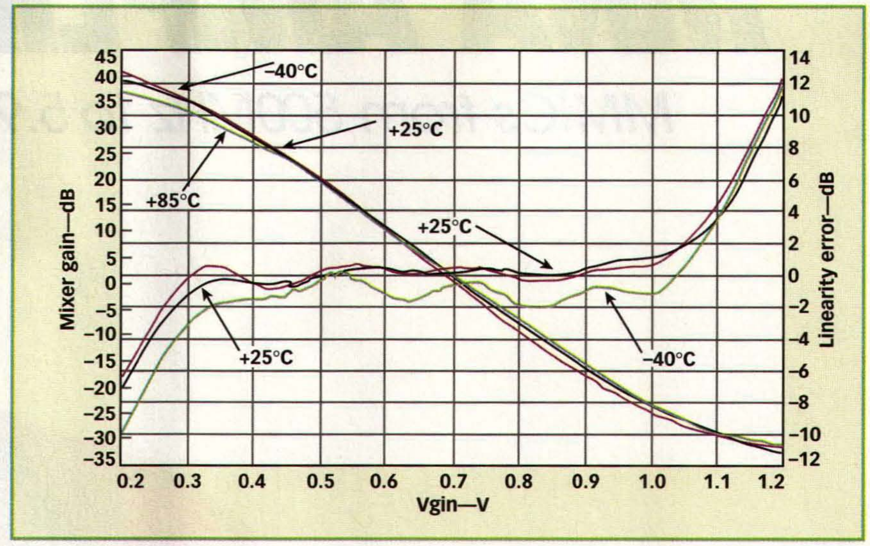
Since gain control in a direct-conversion design must be implemented at



2. The AD8347 is comprised of a 70-dB VGA with AGC mode, an I/Q demodulator and two 30-dB-gain baseband amplifiers. An internal +1-VDC voltage reference provides biasing.

RF and/or at baseband, the AD8347 employs three stages of VGA. Two stages are employed at RF and one at baseband, following the I/Q demodulator. The three VGA stages, which have a convenient linear-in-dB gain-control relationship, are controlled in parallel. Each of the two RF VGAs has a gain range from –10 to +13 dB. The combined gain range of the mixer and the baseband VGA is –10 to +14 dBm. The overall gain range from the RF input to the mixer output is therefore –30 to +40 dB.

The gain of the VGA is set by the voltage on the AD8347's VGIN pin, which is a high-impedance input port. **Figure 3** shows a plot of the gain versus gain-control voltage, along with the linearity of the gain-control function. Note that the sense of the gain-control voltage is negative. As the gain-control voltage increases from +0.2 to +1.2 VDC, the gain decreases from +40 to –30 dB.



3. The three-stage VGA (two stages at RF, one stage at baseband) varies gain from –30 to +40 dB. The gain-control function is linear-in-dB over its range.

The VGA can be driven by an external voltage source [generally a digital-to-analog converter (DAC)] or by an automatic-gain-control (AGC) circuit built into the device. The AGC circuit consists of two root-mean-square (RMS) detectors and an error amplifier. When the AGC circuit is being used, the two mixer outputs are connected to the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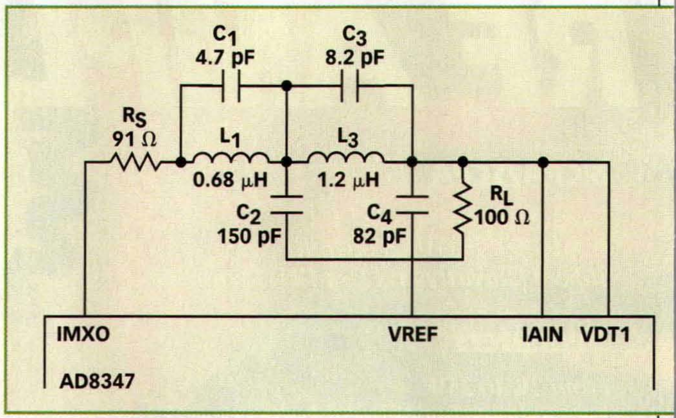


4. The demodulated output (baseband-mixer output) can be filtered off-chip before being applied to the final baseband amplifiers. The on-chip reference voltage signal (VREF) provides biasing for the filter circuit.

inputs of the two detectors. The signals (currents) from the detectors are compared with a set-point signal and an error signal is generated. The AGC circuit is completed by connecting the error signal to the Rx's VGIN gain-control input pin. With the AGC circuit activated, the mixer's output will remain constant for input levels from –55 to + 5 dBm. Because this output has a 90-MHz bandwidth, downconversion to a low IF is also possible.

The mixer is a quadrature demodulator between the RF and baseband VGAs. It produces in-phase (I) and quadrature (Q) baseband outputs. To achieve low error-vector magnitude (EVM) in (direct-conversion) digital demodulation, precise quadrature splitting and amplitude balance of the LO signal is required. The AD8347 achieves typical phase and amplitude balances of 3 deg. and 0.3 dB, respectively, from 0.8 to 2.7 GHz.

LO leakage within a direct-conversion system is one of the key challenges to implementing a high-sensitivity direct-conversion Rx. In direct-conversion and superheterodyne Rxs, some of the LO signal will leak through to the RF input. LO leakage to the RF input will cause self-mixing, which will produce a troublesome DC component at the mixer output. This DC component, if large enough, can lead to saturation of the baseband output signal (to either rail). In addition, because LO leakage is typically frequency dependent, the extent of the DC offset will also vary with frequency, making simple offset compensation difficult.

In a conventional Rx, even if the first downconversion produces a DC component, this component will be harmless as it will be removed by IF filtering. This is an argument for using a direct-conversion Rx to mix the signal down to a low IF (instead of all the way to baseband) and digitizing those signals using IF sampling. The 90-MHz bandwidth of the AD8347's mixer output easily facilitates this.

The AD8347 uses two techniques to minimize the effects of LO leakage. First, the use of an active mixer means that the LO level can be set quite low. In the case of the AD8347,

the recommended level is –8 dBm.

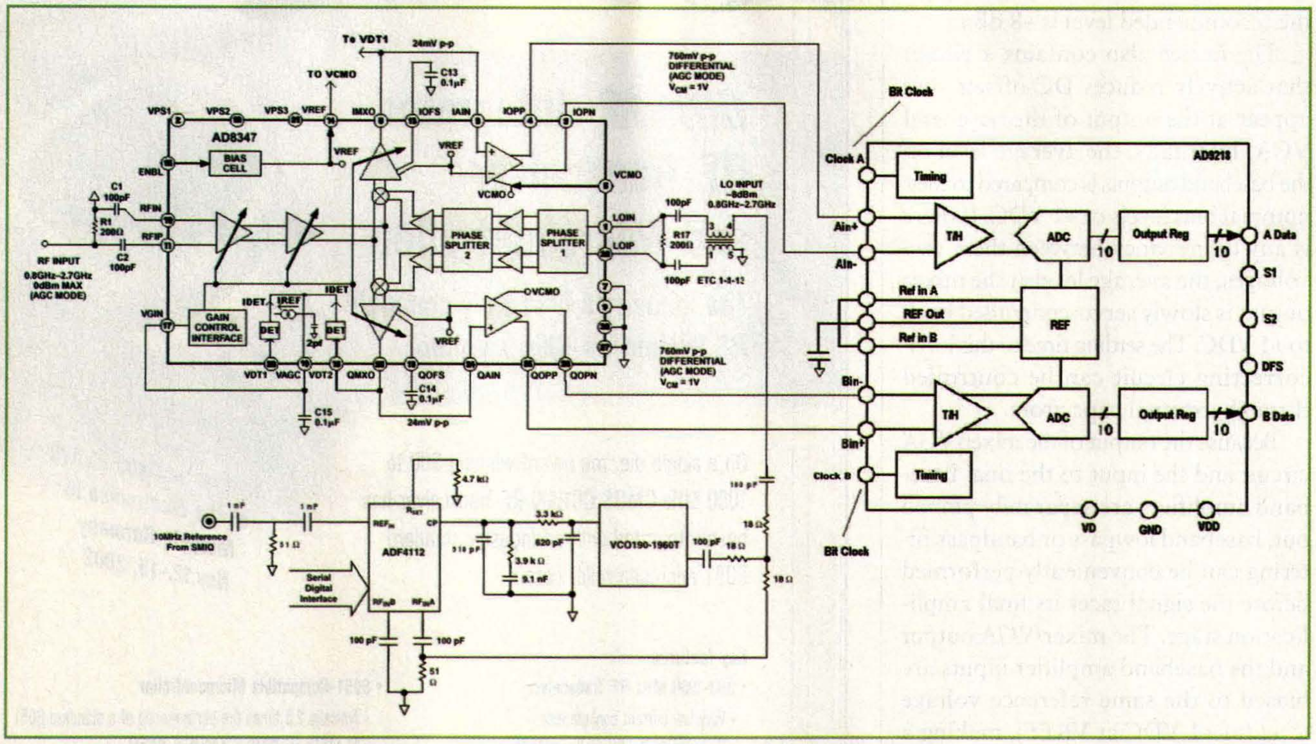
The device also contains a circuit that actively reduces DC offsets that appear at the output of the baseband VGA. Internally, the average level on the baseband outputs is compared to their nominal bias levels of +1 VDC. If there is any discrepancy between these two voltages, the average level at the mixer output is slowly servo-controlled back to +1 VDC. The settling time to this level-correcting circuit can be controlled through external capacitors.

Because the output of the mixer/VGA circuit and the input to the final baseband amplifiers are separately pinned out, baseband lowpass or bandpass filtering can be conveniently performed before the signal faces its final amplification stage. The mixer/VGA output and the baseband amplifier inputs are biased to the same reference voltage level (of +1 VDC at VREF), making a DC-coupled connection permissible.

Figure 4 shows a schematic diagram for a 100-Ω, fourth-order elliptic lowpass filter with a 3-dB cutoff of 20 MHz. Source and load impedances of approximately 100 Ω ensure that the filter experiences a matched source and load. This also ensures that the mixer output is driving an overall load of 200 Ω. Note that the shunt-termination resistor is tied to the reference voltage VREF and not to ground.

The AD8347's baseband amplifiers take single-ended input signals and boost them by 30 dB to produce a differential output which can be independently biased. The VOCM input pin, which sets the output common-mode level, can be driven by the AD8347's internal +1-VDC reference. Alternatively, the VOCM pin can be driven by an external reference voltage. In general, when the VOCM pin is driven externally, the drive voltage should come from the ADC that the AD8347 is driving. The differential outputs are capable of swinging from +0.4 VDC above ground to within +1.3 VDC of the supply voltage and have a 3-dB bandwidth of 65 MHz.

Figure 5 shows a block diagram of a complete Rx signal chain that can be used to demodulate various signal types,

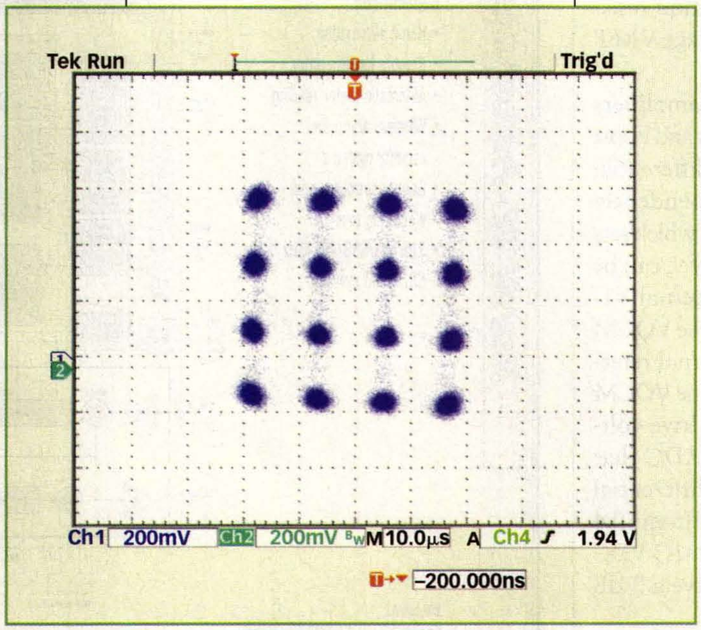


5. A complete direct-conversion Rx can be assembled using the ADF4112, AD8347, and AD9218 ICs.

including higher-order quadrature-amplitude-modulation (QAM) signals. The evaluation system includes the ADF4112 phase-locked loop (PLL), with a range of 0.2 to 3 GHz, which easily covers the 0.8-to-2.7-GHz LO range of the AD8347. In this evaluation system, a 1.9-GHz voltage-controlled oscillator (VCO) was used with the PLL, and a 1:1 balun was inserted between the PLL and the AD8347's LO input to provide a differential drive.

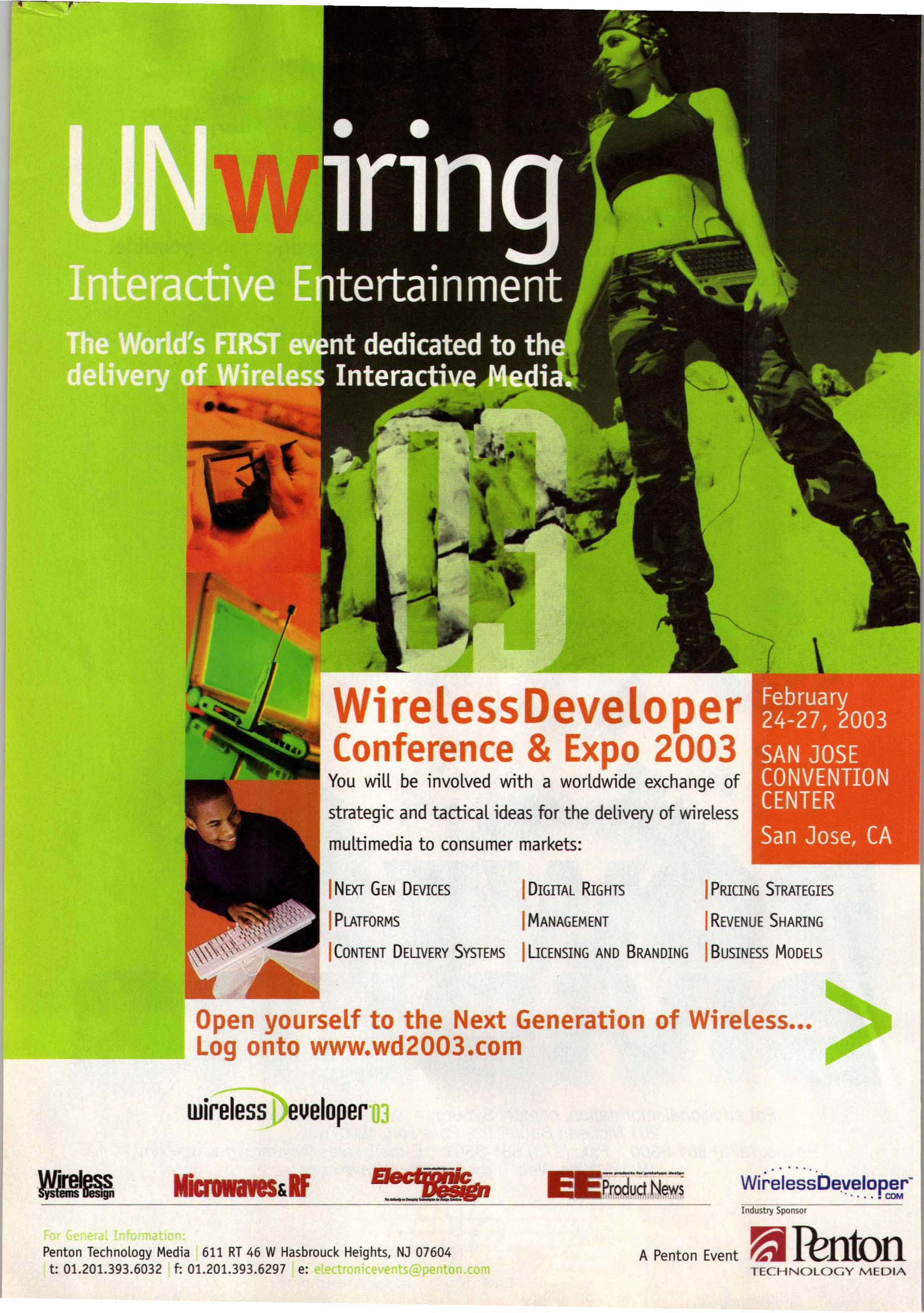
The I/Q outputs of the AD8347, biased to the AD8347's internal reference voltage, connect directly to the differential inputs of the AD9218 dual ADC. The AD9218 is a dual 10-b device available for sampling rates of 40, 65, 80, and 105 MSamples/s (the 105-MSamples/s version was used in this measurement setup). For lower-order modulation schemes, it is possible to use the AD9288, a dual 8-b ADC with versions available for rates of 40, 60, 80, and 100 MSamples/s.

The high-encode-rate capability and high analog bandwidth of the AD8347 also make possible IF sampling applications. By running a 1.9-GHz LO with RF signals at 1.93 GHz, a (modulated) 30-MHz frequency offset results. This 30-MHz offset (and including the frequency deviations of the modulation) is well-within the 65-MHz bandwidth of the AD8347's output amplifiers, as well as the analog bandwidth of the AD9218 ADC. The AD9218 successfully mixed down these 30-MHz offset signals to baseband frequencies, showing the AD8347/AD9218 combination to be suitable for some IF sampling applications. To evaluate the AD8347 as a direct-conversion Rx operating with complex modulation, RF input signals to the AD8347 were supplied from an SMIQ-series vector-signal generator from Rohde & Schwarz (Munich, Germany). The instrument is capable of providing clean 1.9-GHz RF signals with a variety of modulation formats, including 16QAM and 64QAM.



6. Using a reconstruction DAC, the (digitized) demodulated constellation for a 2-MSymbol/s, 16-QAM signal can be displayed on a standard oscilloscope screen.

The AD8347 and ADF4112 can operate at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supply voltages from +3 to +5 VDC. For the evaluation setup, a +3-VDC supply was used, matching the power-supply level of the AD9218. Baseband filtering prior to final output amplification (to improve performance through the elimination of out-of-band noise) is possible on the AD8347 evaluation board, but was not done during this evaluation. The AD8347's VGA was set to run in AGC mode. In this mode, the mixer output settles to a level of approximately 24 mV peak to peak, resulting in a 760-mV peak-to-peak differential voltage at the baseband amplifier outputs. In addition to baseband lowpass filtering, the signal-to-noise ratio (SNR) of the demodulated signal can be improved by increasing the mixer output levels beyond this nominal 24-mV peak-to-peak level.[1]

With an input range from 0.8 to 2.7 GHz, the AD8347 is suitable for a broad range of markets. For systems operating beyond 2.7 GHz, it can also be used as an IF-to-baseband converter.

The standard ADF4112 PLL printed-circuit board (PCB) is shipped with an 800-MHz external VCO. For this evaluation of the AD8347, the PLL module's 800-MHz VCO was replaced with a 1.9-GHz VCO. Tuning of the AD4112's output frequency was easily accomplished through the parallel port using a software package supplied with the PLL by Analog Devices. The PLL module's PCB also features an onboard 10-MHz crystal-oscillator reference source, which was bypassed to allow for synchronization with external RF source (the SMIQ-series vector-signal generator).

Before measurements could be made, the evaluation board for the AD9218 ADC required some modifications to enable common clocking and to meet

the limited drive capability of the clock source. The bit clock from the SMIQ-series vector-signal generator supplied the required encode clock for the AD9218. For a 2-Msymbol/s data rate, this corresponded to an 8-MHz clock rate for 16QAM. The analog input 50-Ω termination resistors on the PCB were switched to 1-kΩ terminations to accommodate the limited drive capability of the AD8347's baseband output amplifiers. This resulted in approximately 400-mV signal swings to the ADC (which has a full-scale input range of 500 mV). To minimize transmission-line effects, this meant keeping cabling between boards as short as possible. The evaluation setup supported the display of 16QAM and 64QAM constellations by reconstructing the ADC outputs using an AD9763 DAC and displaying the I and Q outputs on an oscilloscope in X-Y mode **(Fig. 6)**.

With an input range from 0.8 to 2.7 GHz, the AD8347 is suitable for a broad range of markets. Applications include point-to-point and point-to-multipoint radios, built-in-test-equipment (BITE) systems in cellular base stations, and auxiliary Rx systems in linear high-power amplifiers (HPAs). For systems operating beyond 2.7 GHz, it can also be used as an IF-to-baseband converter. MRF

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Low-Power Transceiver Targets Wireless Headsets

A low-power CMOS transceiver uses TDD techniques within unlicensed ISM bands in support of compact, low-cost wireless headset designs.

Conservation of power is a critical design goal in many wireless products, including wireless headsets for digital radio communications. One "power-wise" approach to wireless audio transmissions involves sampling, digitizing, and compressing audio signals before they are transmitted as the modulated portion of a RF carrier. Upon reception, these signals are decompressed and converted back to analog audio signals. By using time-division-duplex (TDD) techniques, it is possible to realize a low-cost, half-duplex RF transceiver (the CC1000 from Chipcon) that can transmit and receive audio signals with a low-component-count design that is suitable for wireless headsets.

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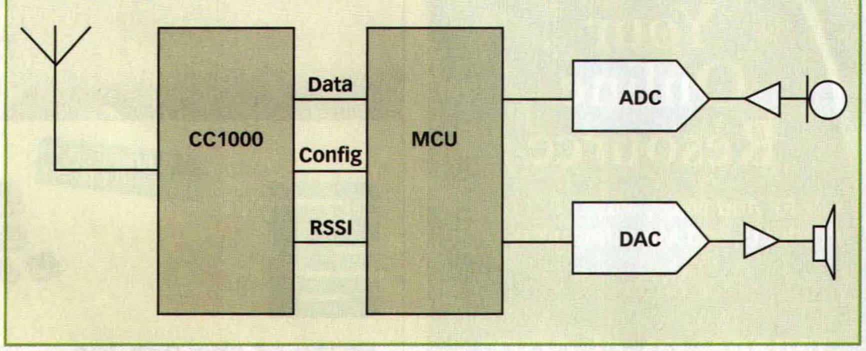
Stricter regulations regarding the vehicular use of mobile telephones, as well as fear of RF radiation close to the brain, have prompted increased sales of wireless headsets for use with mobile telephones. Bluetooth has been touted as a "driving" standard for such applications as wireless headsets, but it remains to be seen if manufacturers of Bluetooth semiconductors can meet demanding market requirements for a low price. As a result, designers of wireless headsets are anxiously seeking low-cost, low-power alternatives to Bluetooth integrated circuits (ICs), such as the single-chip model CC1000 RF transceiver from Chipcon (Oslo, Norway).

Based on 0.35-μm complementary-metal-oxide-semiconductor (CMOS) technology, the CC1000 represents a combination of low cost, high integration, high performance, and flexibility in a



1. This simple functional block diagram represents a wireless headset.

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S5W2	S5W5	N5W5	5	±0.40
S6W2	S6W5	N6W5	6	±0.40
S7W2	S7W5	N7W5	7	±0.60
S8W2	S8W5	N8W5	8	±0.60
S9W2	S9W5	N9W5	9	±0.60
S10W2	S10W5	N10W5	10	±0.60
S12W2	S12W5	N12W5	12	±0.60
S15W2	S15W5	N15W5	15	±0.60
S20W2	S20W5	N20W5	20	±0.60
S30W2	S30W5	N30W5	30	±0.85
S40W2	S40W5	N40W5	40	±0.85

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low-power device. Designed primarily for frequency-shift-keying (FSK) systems in the industrial-scientific-medical (ISM) bands at 315, 433, 868, and 915 MHz, the single-chip transceiver can be programmed for use from 300 to 1000 MHz. It operates on supply voltages from +2.1 to +3.6 VDC, and only consumes 7.4 mA at +3 VDC in receive mode. The leakage current is only 0.2 μA, ensuring miniscule draw on batteries during nonoperating times. The transceiver chip features receiver (Rx) sensitivity of –110 dBm (at 433 MHz and 1.2 kb/s) supports data rates from 0.6 to 76.8 kb/s.

In a digital telephone system, analog voice signals are converted to digital signals through pulse-code modulation (PCM), using three steps: sampling, quantizing, and coding. Band-limited (4-kHz-wide) voice signals are sampled at a rate of 8 kHz (in agreement with Nyquist theory). The amplitude of the voice signal is sampled (measured) every 125 μs. Each sample is then quantized (or truncated) into a number, usually an integer. For example, if 13 b is used, this integer could be between –4096 and +4095. Coding is the way these quantization levels are represented as digital numbers. For example, the coding

In a digital telephone system, analog voice signals are converted to digital signals through PCM, using three steps: sampling, quantizing, and coding.

method known as "two's complement" may be used to express negative, as well as positive, numbers. Most of the information captured for human speech has a small-signal character, contained within higher-resolution, smaller amplitudes. For less-likely larger-amplitude voice signals, the use of a uniform quantizer (equally spaced digitizing steps) provides high, but unnecessary, quality. The uniform quantizer can also yield pronounced truncation effects for the more frequent small-amplitude signals. As a result, using nonuniform quantization provides a system that is more appropriate for human speech.

Nonuniform quantization can be achieved by passing a voice signal through a compressor at the transmit end, and then passing the signal though

an expander on the receiving end as part of a process known as "companding." By using companding, the required code-length word can be reduced from 13 b to 8 b or less, while retaining the subjective quality of the voice signal. Companding can be performed in hardware in a coder/decoder (codec) circuit or in software using a look-up table or a real-time calculation. Two international standards for creating 8-b encoded data are u-law and A-law. In the US and Japan the accepted standard is u-law, while A-law is used in Europe.[1] The 8-kHz sample rate combined with companding leads to an 8-b code word. The digital voice stream is therefore said to be 64 kb/s.

A public-telephone network is an example of a full-duplex system, where speech is transmitted in both directions at the same time. In a half-duplex system, speech travels only in one direction at one time (similar to a walkie-talkie system). As an extension of the public-phone network, a wireless headset must, therefore, be full duplex. Full-duplex systems require more complex circuit solutions than half-duplex systems, where the Rx and transmitter (Tx) can share many of the system function blocks. A half-duplex approach can save space and cost.

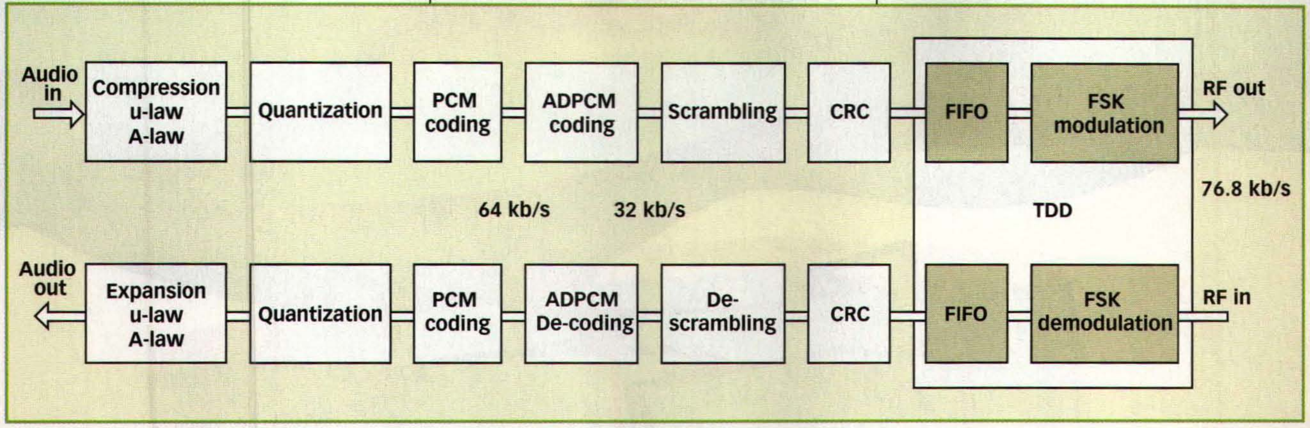
A public-telephone network is an example of a full-duplex system, where speech is transmitted in both directions at the same time. In a half-duplex system, speech travels only in one direction at one time.

By using TDD, full-duplex operation can be achieved with half-duplex cost and simplicity. Using TDD, the signal is transmitted one way at a time, but the direction of transmission is switched very fast with a small latency (time delay). As long as the latency is in the order of 100 ms or less, the human ear will not detect it and a normal conversation can occur. In comparison, satellite telephone systems have a large delay, making a normal conversation flow more difficult. Using TDD makes it necessary to buffer the digital voice stream from one party while the other is transmitting. A voice stream of 64 kb/s, therefore, would require a wireless TDD data link of at least 128 kb/s. The turn-around time from Rx to Tx would require an even high-

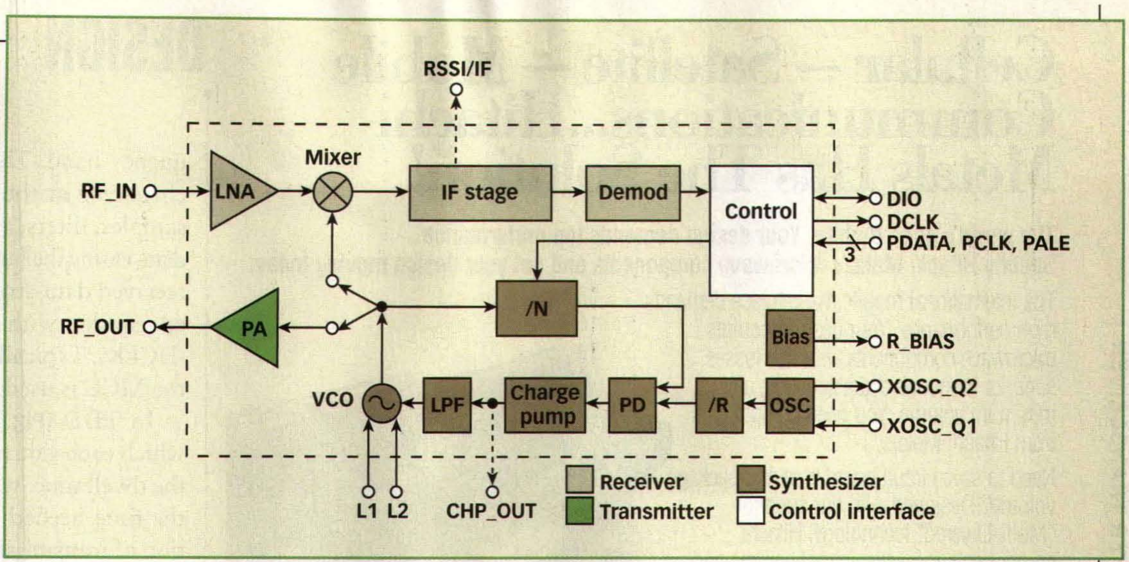
er data rate.

High data rates require larger RF bandwidths or advanced modulation techniques. To reduce the digital-voice data rate to be transferred, another layer of coding is required, such as Adaptive Differential Pulse Code Modulation (ADPCM) or Continuous Variable Slope Delta coding (CVSD). Each scheme is based on differential coding—instead of sending the absolute value of the sample, the difference between the current sample and the previous one is sent. Using ADPCM coding, 8 b are coded down to 4, 3, or 2 b. A data rate of 64 kb/s is then reduced to 32, 24, or 16 kb/s. Assume now the use of a 32-kb/s ADPCM, since this form of compression does not place a heavy burden on the system microcontroller. Dedicated hardware implementations could also be used for the compander and the ADPCM codec.

Figure 1 shows the block diagram for a wireless headset solution, with the signal flow shown in **Fig. 2.** A functional diagram of the CC1000 is shown



2. The signal flow in a wireless headset is shown in this diagram.



3. This block diagram illustrates the key functions contained within the CC1000 transceiver IC.

in **Fig. 3**. As can be seen, the IC contains components for the Tx, Rx, frequency synthesizer, and for control functions. Few external components are required for operation, allowing the transceiver IC to support applications requiring low-target selling prices, such as wireless headsets. At 433 MHz, the CC1000 consumes only 7.4-mA current when receiving and only 10.4-mA current when transmitting a 0-dBm signal.

With TDD, it is important that the Rx/Tx turn time is short to keep the overhead down and, therefore, the overall data rate down. The CC1000 phase-locked loop (PLL) provides turn-around times of less than 200 µs. This is also important in the idle mode where the earpiece is polling for an incoming call. When polling for an incoming call, the received-signal-strength-indicator (RSSI) circuitry can be used to quickly determine whether or not there is a signal. The CC1000 provides an analog RSSI signal that can be connected to an analog-to-digital converter (ADC), preferably integrated in the microcontroller unit (MCU). The CC1000 contains a programmable PLL that support the use of several frequencies or channels. If one channel is occupied, an automatic channel-selection algorithm can be used to find a free channel to avoid interference with other radio systems in the same fre-

quency band. The integrated bit-synchronizer in the CC1000 internally samples, filters, and slices the received data, easing the burden of the MCU. The received data-stream (DIO) is provided together with a synchronous clock (DCLK). Typically, an interrupt pin of the MCU is used for the clock.

In TDD **(Fig. 4)**, the time during which each side transmits is known as the dwell time, while the guard time is the time needed to change the direction of transmission. Overhead can be reduced by keeping the dwell time long and the guard time short, but using a long dwell time introduces longer latency. A dwell time of 50 ms represents a good compromise, providing a repetition rate of 100 ms or 10 Hz. A first-in, first-out (FIFO) buffer is used to buffer the data sent and data received during TDD. The FIFO is usually implemented in the microcontroller random-access memory (RAM) as a software FIFO. A state machine in the microcontroller controls the TDD and adds the control information. The 32-kb/s voice data is therefore transmitted at 76.8 kb/s. This includes the minimum bidirectional voice-data requirement of 64 kb/s, additional control information, and guard time.

In TDD, the time during which each side transmits is known as the dwell time, while guard time is the time needed to change the direction of transmission.

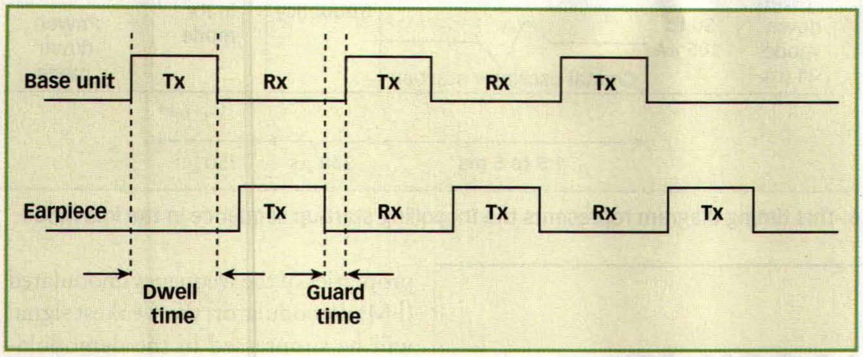
Figure 5 shows a suggested packet format. The frame consists of a preamble that is used by the Rx to synchronize to the incoming data and set the slicing threshold in the data slicer. The "start of frame" is a unique term used to separate the preamble from the address and control information field. The bulk

of the packet will be the voice data. A check sum should follow the voice data and can be used by the Rx to check the integrity of the received data.

A quality-of-service (QoS) measure can be defined based on the received data. A Cyclic Redundancy Checksum (CRC) can be added to provide a simple QoS solution. The QoS measurement can also be used to make an automatic frequency selection if the present channel is not working satisfactorily. With a digital radio system, scrambling or even encryption can be added to protect the privacy of a transmission. In most cases, scrambling is sufficient because the range of the system is small compared to what can be eavesdropped acoustically. Directional antennas could be used in a potential eavesdropping scenario, but very sensitive or confidential information should not be shared over a telephone in any case. Also, it would be pointless to make a wireless headset more secure than the rest of the telephone network. Encryption is a less attractive option because it significantly increases signal-processing requirements when implemented in software, defeating the benefits of a low-cost, low-power solution.

In idle mode, a wireless earpiece waits for an incoming call. This is performed using Rx polling which means that the Rx is turned on at regular intervals in search of a valid signal **(Fig. 6)**. A typical polling interval is 1 s: once every second, the wireless earpiece Rx is turned on and looks for a signal. First, the RSSI can be checked. If a signal is detected, the MCU starts to look for the preamble in the received data stream. It requires 11 b to fill the averaging filter in the data slicer and from 4 to 8 b to detect a valid preamble. Thus, a single poll requires a minimum of 19 b-periods or 250 μs using 76.8 kb/s. In addition, it takes approximately 250 μs for the PLL to lock after crystal startup. In the worst case, each poll is then 0.5 ms, yielding a polling ratio of 1 s / 0.5 ms = 2000:1. The contribution to the average current consumption in idle mode is, therefore, less than 10 mA/2000 = 5 uA.

The ADC/DAC, compander, and ADPCM or CSVD can be implemented in various ways (Fig. 2). Some manufacturers provide hardware solutions integrating several or all these functions, but digital-signal-processing (DSP)/MCU solutions can also be used. For example, models CMX639 (CVSD) and CMX649 (ADM) are two voice codecs provided by CML Microcircuits (www.cmlmicro.com), while models MC145540 and MC145481 are ADPCM codecs from Motorola (www.motorola.com). Several ADPCM codecs, including compander functions in the ML7029 and MSM7540L/7560L/7570L/7590L ICs are available from Oki Semiconductor (www.okisemi.com). ADPCM coding and u-law/A-law companding can also be performed in an MCU (from Cypress Semiconductor) or DSP (with solutions available from suppliers such as Texas Instruments and Lucent Technologies). Finally, the ADSP-21ESP202 series of embedded speech processors from Analog Devices (www.analogdevices.com) combine the ADSP-218x 16-b fixed-point DSP core, advanced mixed-signal technology, and software intellectual property (IP) for high-performance speech-processing applications.

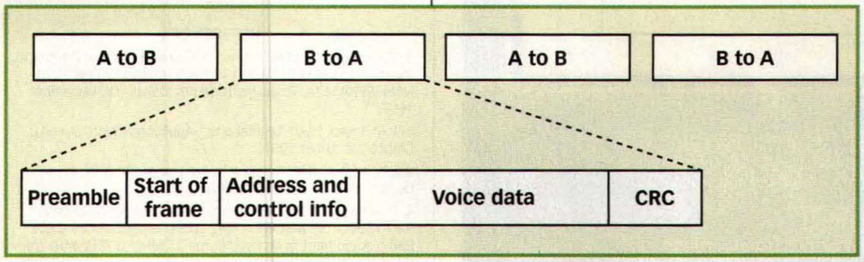


4. TDD makes possible effective full-duplex communications by quickly switching the direction of transmissions between the earpiece and the base unit connected to a cellular telephone.

In the US, the use of radio Txs and Rxs is regulated and approved by the Federal Communications Commission (FCC). A few frequency bands, the so-called ISM bands are dedicated to license-free operation. The most attractive of these bands is 902 to 928 MHz as regulated by FCC CFR 47, part 15.249.[5] The Tx is allowed to generate a field strength up to 50 mV/m as measured at 3 m, equivalent to –1-dBm effective radiated power (ERP). This is more than sufficient for the very short range required in this application. The frequency band is 26 MHz wide, which makes it possible to use several channels at the same time. For example, the channels can be placed at 1-MHz spacing, supporting up to 24 channels.

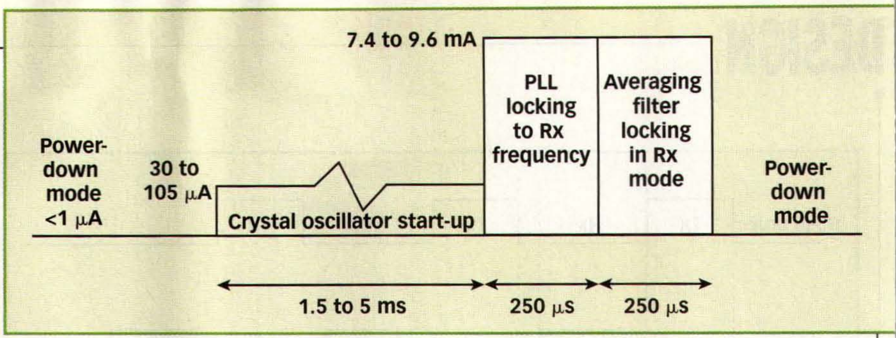
In Europe, two unlicensed radio bands below 1 GHz should be considered: 433 MHz and 863 MHz. The latest revision of the CEPT 70-03E recommendation[3] notes that "audio and voice signals should be avoided in the band 433.05 to 434.79 MHz." This implies that national bodies in Europe could totally ban such applications in this band (which is not yet harmonized). Therefore, this frequency band should not be used for wireless headsets targeting the EU/EEA countries. A better option is the band at 863 to 865 MHz that are specifically set aside for wireless headset applications. Up to 10 mW (ERP) is permitted in this frequency band. The minimum recommended channel spacing when the CC1000 is used is 500 kHz, supporting three or four channels in the 863-to-865-MHz band. Consult ref. 2 for a summary of regulatory issues.

A multichannel system could be an advantage in a crowded area to avoid interference from other wireless headsets or systems using the same frequency band. A software algorithm could select the channel or frequency automatically. For example, the base at the handset could use the RSSI to scan for a free channel and choose the best at any moment when setting up a new session (a new incoming or outgoing call). The earpiece could then simply scan all channels when polling in the idle mode. This scheme would increase the power consumption in the idle mode of the earpiece due to the scanning, but it would also improve the reliability of the system.



5. This suggested packet format consists of a preamble, start of frame, address and control information, voice data, and CRC.

The co-location properties of a radio system are usually expressed in co-channel and adjacent-channel rejection. The co-channel rejection is the strength of the interfering signal compared to the wanted signal when operating at the same channel. Due to the properties of the frequency-modulated (FM) demodulator, the weakest signal will be suppressed in the demodulation process. Using CC1000, the interfering signal can be up to –3 dBc, which is 3 dB below the wanted signal.



6. This timing diagram represents the Rx polling start-up sequence in the idle mode.

Blocking performance is a measure of the ability to withstand strong out-of-band signals. As the cell phone itself is operating at a few megahertz away from the operating frequency of the system (863 or 915 MHz), it is important to provide sufficient out-of-band selectivity. For a frequency offset of ±1 MHz, the CC1000 delivers 43-dB blocking (compared to 30 dB required by the EN 300 220, Class 2 standard[4]). For an offset of ±2 MHz, the CC1000 offers 49-dB blocking (compared to 35 dB required by the EN 300 220 standard). For an offset of ±3 MHz, the CC1000 achieves 68-dB blocking (compared to 50 dB for EN 300 220). For an offset of ±4 MHz, the CC1000 reaches 72-dB blocking (compared to 60 dB for EN 300 220).

Power-supply design in a headset is very important for the total battery lifetime. The use pattern of a wireless headset implies a rechargeable battery technology. This could be nickel metal hydride (NiMH) [being more environmental friendly than nickel cadmium (NiCd)] or lithium ion (Li-ion). One- or two-cell boost converters are available from several vendors, such as the TPS61000 series from Texas Instruments. MRF

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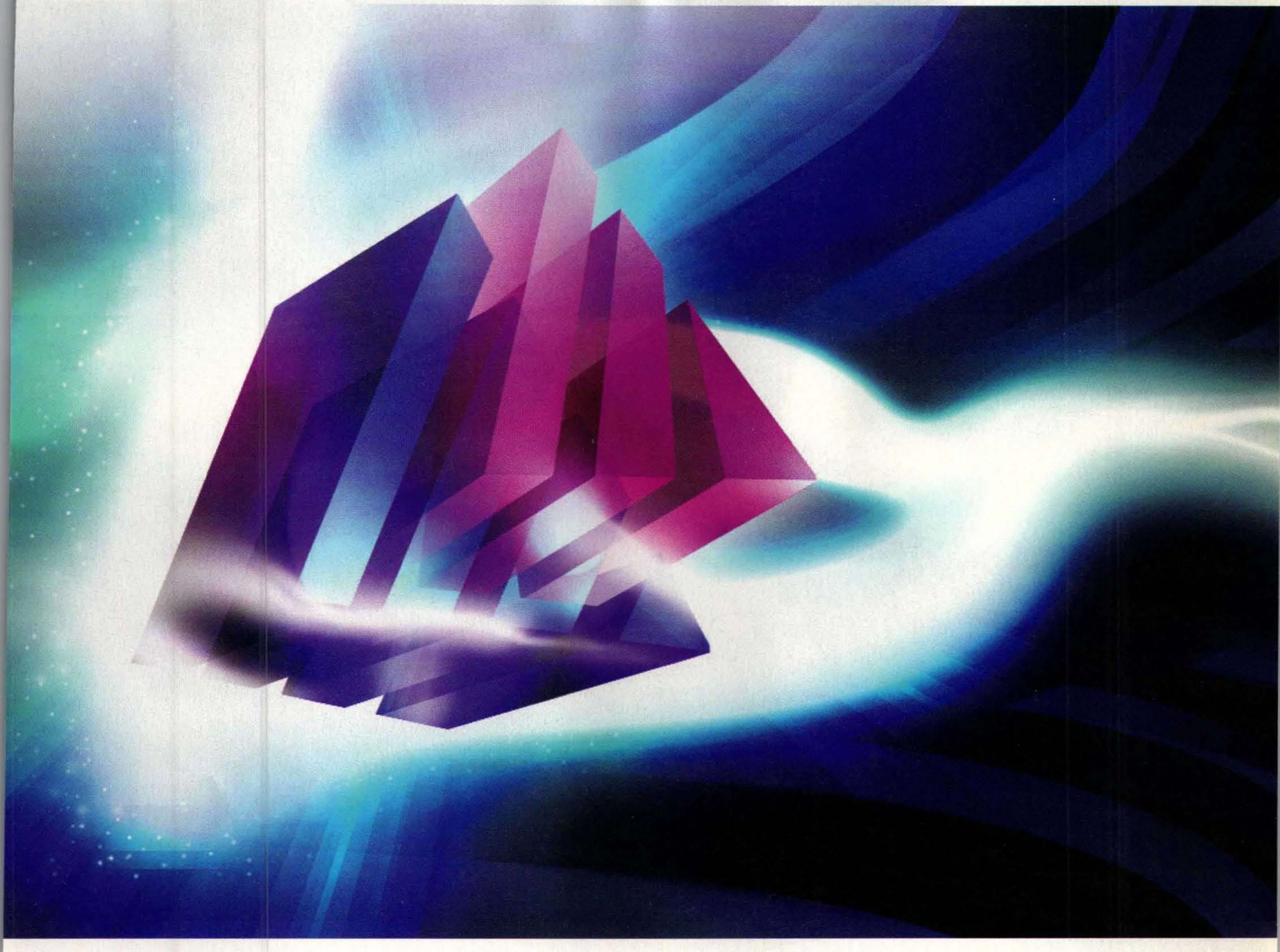

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Communications-system design is complex, requiring practical and powerful design tools. Complex interactions between RF components, baseband signal processors, and increasingly complex modulation schemes can challenge even the most experienced designer. Fortunately, modern electronic-design-automation (EDA) technology can help overcome these challenges with a more seamless design flow. What follows is an examination of a top-down/bottom-up design-flow approach based on the use of advanced EDA tools. To demonstrate the approach, an IEEE 802.11a wireless local-area-network (WLAN) integrated-circuit (IC) design will be used as an example, although the principles are applicable to other communications standards and other design topologies, such as RF printed-circuit boards (PCBs) and multichip modules (MCMs).

To create a communications architecture, an engineer must consider the technical boundary conditions of the physical layer (PHY). Consider a WLAN based on offset frequency-division-multiplex (OFDM) signals. Data rates to 54 Mb/s are achieved by using higher-order quadrature-amplitude-modulation (QAM) formats and 53 subcarriers that share frequency spectrum with adjacent orthogonal subcarriers. With these lower-rate parallel subcarriers, the relative amount of time dispersion caused by delay spread is decreased, and with an adequate guard interval, inter-symbol interference (ISI) is almost eliminated. While these characteristics make for a high-speed communications link, they also introduce design challenges:

1. Sensitivity to frequency offset—good frequency correction is needed in the receiver (Rx) to ensure good inter-carrier interference performance (ICI).
2. Sensitivity to oscillator phase noise for best bit-error rate (BER) at high order QAM.
3. Channel estimation is used to detect and remove delay spread.
4. The complexity of inverse Fast Fourier transform/Fast Fourier transform (IFFT/FFT) required to optimize latency and performance.
5. Maintaining orthogonality under high-power conditions.
6. High peak to average ratios strain power-amplifier (PA) performance.

Due to the complex modulation scheme of OFDM signals, with multiple subcarriers and critical timing requirements, performance of the system cannot be determined unless the modulation is considered, circuit interactions are taken into account, and RF/baseband inter-

actions are evaluated. Considering the issues, it is no wonder that communications-system design is complex and time consuming. But if an EDA tool has a design and verification environment that is tailored to the communications standard, a designer should be able to generate a viable design is less time, and quickly verify it to obtain the best chance at a first-pass success.

The basic system design flow is a top-down, bottom-up design flow following these steps:

High-level architecture
Base-system design
Optimize system design
System verification
Functional block/circuit design
Functional block verification
Lower-level implementation

This top-to-bottom flow involves RF and analog-mixed-signal (AMS) design that can be used for RF system/baseband and digital-signal-processing (DSP)/baseband system designs, which are typically designed in parallel. For RF/mixed-signal IC applications, this design flow is currently undergoing further refinement by Agilent Technologies (Santa Rosa, CA) and Cadence Design Systems (San Jose, CA) as part of a five-year technology alliance announced in February.

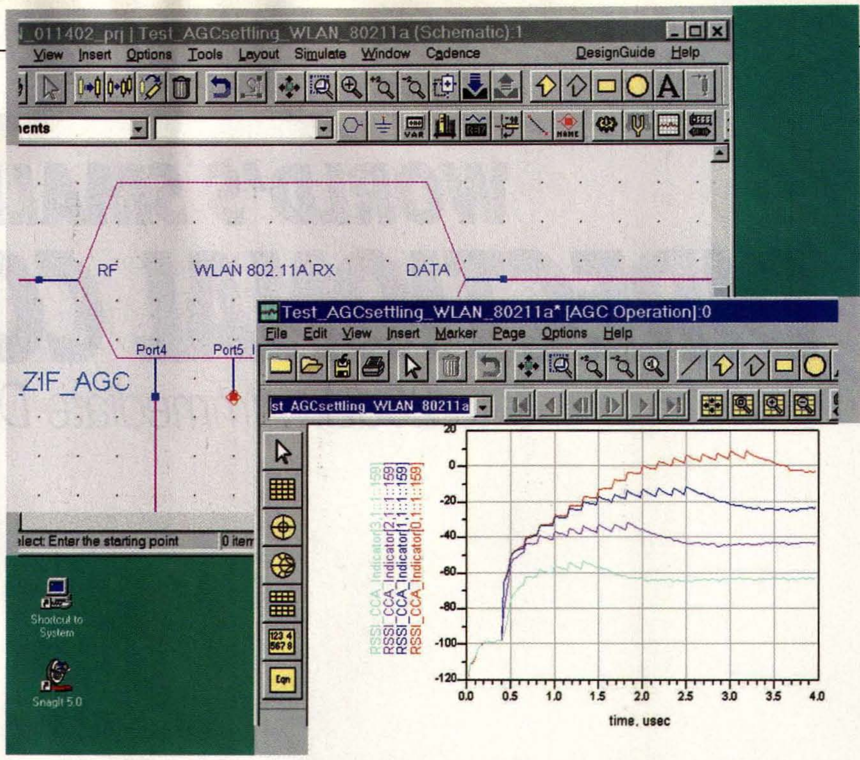
To handle the WLAN example, Agilent Ptolemy, a dataflow manager with embedded system design capability that is available in the Advanced Design System (ADS) design environment from Agilent Technologies, will be used. The ADS design and verification environment library available for WLAN 802.11a will also be used.

Before proceeding, it might help to review some of the EDA tool attributes **(see table)** that should be examined prior to taking on a complex design such as a WLAN. RF/baseband and DSP/baseband engineers typically collaborate to determine architecture partitioning. Algorithm-based tools and spreadsheets play an important role in this design area and it is often desirable to import or re-use these algorithms in the system-design tool. Since each communications standard (such as IEEE 802.11) puts different constraints on the system design, intellectual-property (IP) reuse from one system to another will be minimal in many cases, although it would be desirable to have access to IP specific to an application to speed the design process. Fortunately, within ADS, the Agilent WLAN Design Library and WLAN DesignGuide provide much of the needed application-specific expertise to simplify a WLAN design.

A rough idea of the RF/mixed-signal design partitioning can usually be developed early in the conceptual design phase. To speed this process, a reference Rx, for example, is available in the WLAN DesignGuide that can be used as a baseline in establishing an architecture for the WLAN Rx. In this case, a zero-intermediate-frequency (IF) Rx is suggested. The architecture allows a significant simplification and reduction in analog parts count, and increases flexibility of the Rx. In terms of specific design advantages, this architecture also simplifies the frequency-offset problem encountered in WLAN designs by reducing the number of elements that contribute to frequency errors.

Figure 1 shows a high-level Rx block containing the baseline architecture IP in the WLAN DesignGuide. Pushing down into the next level of system hierarchy reveals more of the architectural details. The simulation results show the system automatic-gain-control (AGC) response using the AGC test available in the DesignGuide. To speed the design process, it is desirable to reuse as much existing IP as possible. This may include behavioral models of RF front ends, circuit high-definition-language (HDL) functions, functional cores, and algorithm import. All of these functions can be used to provide essential implementation paths for circuit and baseband-circuits implementation. By using a simulation backplane similar to Agilent Ptolemy, proven IP such as that used in channel estimation can be reused or refined.

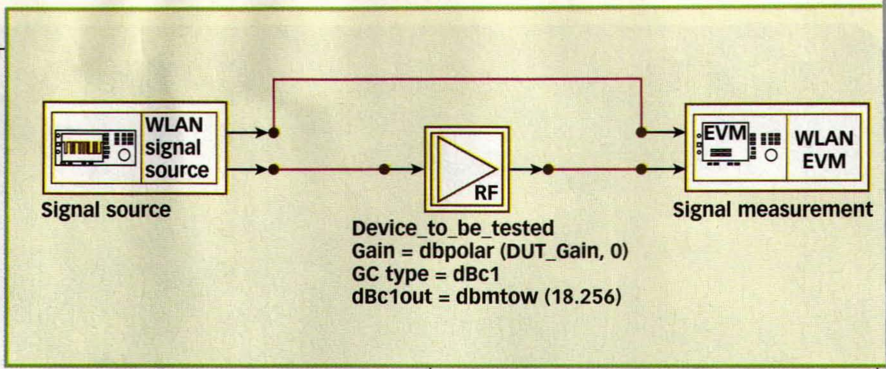
Once the base Rx architecture is determined, the design can be refined using the WLAN library functional blocks, and the ADS hierarchical optimizer available at the system level. At this point, propagation models can also be added to form the basis of a more realistic simulation, and further refinements made if necessary. Verification is the process of performing a detailed check on a design during its development, to determine its viability before proceeding to the next step. Once a



1. This computer screen contains a high-level WLAN Rx architecture in the background and performance simulation of the Rx AGC in the foreground. This depicts an IP available within the WLAN DesignGuide.

first-pass design of the system architecture has been completed, it needs to be verified against the wireless standard before it is implemented.

System-level verification can be performed using the various test benches available in the ADS WLAN Design Library. In the library, a full range of tests is available to verify the PHY design to a specific communications standard revision. A user can elect to insert a subsystem, block design, or circuit and test performance against the WLAN standard. After block implementation, the verification process must be performed again prior to fabrication. After determining a functional system design, system designers usually provide specifications for the functional RF and baseband blocks used by circuit/baseband designers who design the blocks in a form that can be implemented. Synthesis of the active RF and baseband blocks directly may be desirable, but with the high performance requirements, advancing technology, and need for efficient design implementations, designers often do not to embrace these types of tools.



2. As an example of design and verification, an Agilent MGA-82563 PA was evaluated within the ADS environment.

Functional block design usually occurs with a separation between the RF and baseband worlds. One activity of the alliance between Agilent and Cadence is the development of tools which more seamlessly transfer IP back and forth, to support a more comprehensive design flow that permits greater interaction between RF and baseband designers.

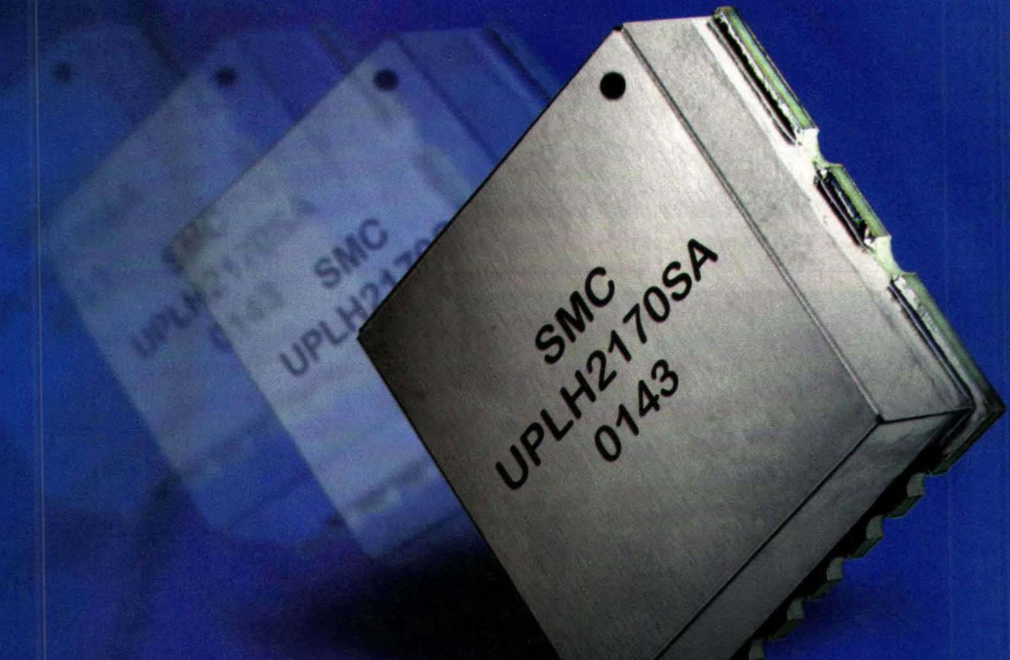
As part of RF/baseband-system-block design, these function blocks must be intimately linked with the system-design environment so the effect of RF/mixed-signal interactions and physical design can be analyzed. Due to the complexity of modern modulation schemes, simple frequency-based simulation is no longer adequate for simulations of wireless-communications function blocks. Even a frequency-based simulator may need to simulate multiple tones with many harmonics and robust harmonic-

Key EDA tool requirements for RF/baseband system design

EDA tool attribute	Simulation requirement
Hierarchical system/circuit representation in a common environment	Needed to verify circuit interaction effects on WLAN system performance and provide an implementation path.
Synchronous timed data-flow manager	Provides a basis for a plug-in framework tool, that can interact with other EDA tools and data sets. Agilent Ptolemy is an example of one such data-flow manager.
Multi-platform support	For maximum flexibility, support for popular Unix and PC platforms facilitates maximum inter-tool connectivity and compatibility with user CAE hardware.
Analog/digital functional blocks and propagation models	Needed to perform full system-level simulation of RF with analog/digital components.
Ability to import/generate C-code algorithms, HDL, and utilize functional cores	Provides basis of IP (intellectual property) re-use and utilization of custom behavioral models. Provides vectors for bottom-up verification of RTL.
System/HDL co-simulation	Provides verification of RF components and baseband components (to the RTL level). Forms an implementation path.
Floating-point simulation	Fast simulation, with a wide array of block and propagation models specifically tailored for the WLAN application.
True fixed-point modeling	True fixed-point simulation provides accurate results for implementing systems like WLAN. Be careful of truncated fixed-point emulation, which is not the same, and sacrifices accuracy. For WLAN systems, higher order bit precision of "2.12" or higher may be required.
RF circuit-block verification	Provides a high abstraction level for basic, steady state RF/AMS behavioral block simulation. Behavioral block models extracted from actual circuit implementation is desirable for fast validation of circuit performance.
System/circuit co-simulation	Provides a means to verify circuit-level time varying performance and physical design effects on system performance. Designers need Circuit Envelope and/or SPICE/convolution to perform effective system/circuit co-simulation to a detailed level.
High-performance harmonic balance engine for co-simulation	Simple steady-state analysis using harmonic balance simulation may still require the ability to handle four or more subcarriers, with multiple harmonics and spurious responses. Krylov solvers and transient assist will speed simulation time and provide better convergence, especially for large circuits used in today's wireless systems.
Time- and frequency-based simulation and modeling capability at the system and circuit level	Frequency-based simulation is needed to determine fast and accurate EVM, ACPR, and spurious results. Both the system- and circuit-analysis tools must have time-based simulation capability to handle the complete implementation of PLLs, AGCs, oscillator stability, switching time, modulators/demodulators etc. Less capability may not catch dynamic circuit problems.
Circuit Envelope simulation	Used to perform circuit-level simulations involving time varying complex modulation. This is the only simulation technology that allows simulation of circuits (as opposed to behavioral models) with time-varying complex modulation.
Tailored application test benches	Fully coded BER, PER, EVM, ACPR are examples of tests that if tailored to the WLAN application, permitting full verification of a design to a communications standard. Test benches provide an easy test environment.
Integrated system/circuit design environment	Provides a common platform with a familiar "look and feel" for system, circuit, and baseband designers, to obtain maximum efficiency in design and verification.
Hierarchical optimization	Provides the capability to optimize circuit-level attributes to obtain best system-level performance.
Yield analysis/Design Centering	If used at both the system and circuit level, these tools can optimize production yield.
EM analysis	Model physical design, isolation, signal contamination (crosstalk and other coupling effects).
Connected simulation/instrumentation solutions	Provide unique solutions to difficult problems. Provides a means of testing EDA designs with external hardware like power amplifiers designed for WLAN applications. Performs a powerful and unique de-bugging capability.
Hierarchical optimization	Provides the capability to optimize circuit-level attributes to obtain best system-level performance.

balance simulators with Krylov subspace solvers and pre-conditioners are needed to obtain the accuracy required in a reasonable amount of time.

Ultimately, however, harmonic-balance simulation is not adequate by itself to analyze complex digital modulation represented by time-varying phase and amplitude information in circuits. WLAN modulation has a very-high peak-to-average ratio that challenges the capabilities of many amplifiers and disturbs the complex vector information, which degrades orthogonality between channels. This degradation cannot be identified with harmonic balance simulation, which is a frequency-based technology with no time-varying information. A better approach is the use of an envelope simulator that uses complex digital modulation for analyzing



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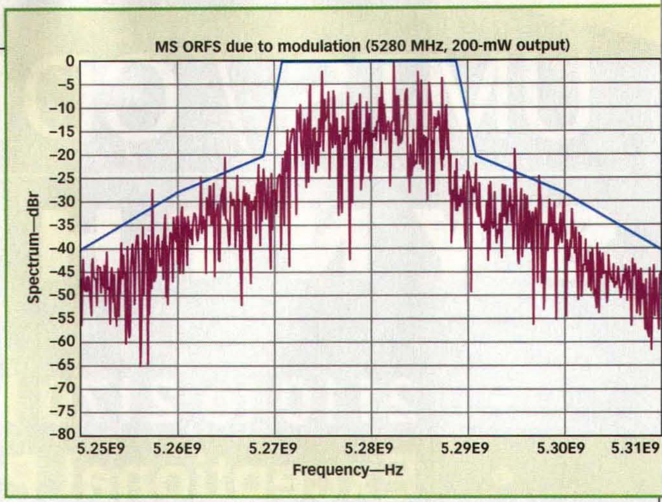

3. The test results of the MGA-82563 PA evaluation are shown at 5280 MHz with 200-mW output power.

the effects of modulation on a design. Agilent's patented Circuit Envelope technology allows the engineer to simulate circuits embedded within a system design in this matter.

Time-based simulation is often overlooked, but dynamic-circuit problems are a major reason why some designs do not achieve first-pass success. For example, the WLAN signal contains a vector, and in an AGC-controlled amplifier chain, dynamic effects of the AGC and PA can distort this vector and cause data errors. Time-based simulation such as Simulation Program for Integrated Circuit Emphasis (SPICE), Convolution, and Circuit Envelope can analyze the dynamic effects of PA droop, phase-locked loops (PLLs), modulators/demodulators (MUX/DeMUX), and RF switching time. Circuit Envelope is also the only commercial simulator that can analyze many of these problems and directly provide the engineer with dynamic frequency versus time information for behavior such as oscillator start up.

WLAN 802.11a circuits involve frequencies in the 5-GHz range, and the physical aspects of the RF design in a dense packaging environment can mean trouble for the circuit designer. An electromagnetic (EM) analysis tool with sufficient speed and capacity can provide valuable insight into potential problems. Tools such as Momentum from Agilent incorporate mesh reduction and quasistatic solvers that enable EM simulation of whole new classes of problems such as signal crosstalk and SMT/BGA packaging analysis. Having a fully integrated EM tool combined with other simulation engines provides many benefits. For RF circuit design, engineers can use a combination of time-domain simulation technology from Cadence and frequency-domain simulation technology from Agilent, including the new RF Design Environment (RFDE) product, the first product available as a result of the Agilent/Cadence alliance. Once the circuit design has been completed, the ADS Ptolemy environment can dynamically link to RF circuit schematics in the Cadence environment for circuit/system verification.

Baseband/DSP designers have their own sets of problems to overcome. Typically, they operate in a nonschematic environment and use the fixed-point specifications handed to them. Their work involves fully synthesizing gates, hand-coding RTL, or reusing IP that is represented using a hardware

description language. As noted earlier, channel-estimator design can be tricky for WLAN systems. There is a need to consider the RF impairments, since they affect the way the DSP timing and clock analysis is done. Therefore, if the RF/baseband and DSP/baseband design can be done in the same environment, IP can be shared between both sets of system designers facilitating the design process.

Once the RF and baseband circuits have been designed, it is desirable to place the block-implementation circuits or RTL back into the system design to check interoperability and verify overall system performance. This is performed using block-substitution methods. System designers can import baseband design blocks into the system-simulation environment using high-definition-language (HDL) wrappers. On the circuit-block side, behavioral model extractions, or more detailed circuit cosimulation is used to port the circuit-block data back to the system designer. Behavioral model extractions can speed up the simulation process at the expense of circuit-behavior detail. These types of simulations allow the designer to validate their system design to a certain level of detail. A comprehensive circuit/system co-simulation is best done using a tool like Circuit Envelope. Using these two processes, a system-verification process can take place.

System verification is best performed using the WLAN library. The Agilent product includes various test benches and is, therefore, more than a library of functional block models. Its value to the WLAN designer includes the ability to simulate the design and verify it to 802.11a standards. This includes testing of adjacent-channel power ratio (ACPR), error-vector magnitude (EVM), BER, and packet-error rate (PER). Verification is done by simply placing the appropriate design block, subsystem or system in the applicable test bed provided in the WLAN library product and running a simulation in ADS. The results are displayed graphically, and include the pass/fail criteria for the 802.11a standard. Various revisions of the standard are provided so testing can be performed to the specified revision level.

Figure 2 shows a WLAN PA block being verified with a subsystem design in the WLAN design and verification environment. In this example, the amplifier could be a behavioral functional block, a circuit design, or a representation of measured data. Preconfigured tests in ADS can verify circuits and systems, including tests such as EVM, BER, and PER. A fully coded BER verification will provide a meaningful verification that includes not only the RF interactions, but much of the baseband

processing as well. This enables the engineer to evaluate IFFT/FFT complexities in equalizers, channel estimators and coders/decoders (codecs), providing the engineer with confidence that the system will have the best chance at a first-pass success and not require expensive design revisions.

Figure 3 offers an example of WLAN transmitter (Tx) verification. This plot shows spectral regrowth of a PA evaluated at an output level of 200 mW. The complete Tx chain can also be evaluated in this manner. These test benches are available for a number of WLAN-related specifications for T/R paths. The capability of connecting simulation and measurement tools is a tremendous advantage when modeling and verifying the performance of modern communications systems. With compatibility between simulation tools and test instruments, for example, complex modulation formats defined in software can be saved as digital files for digital-signal generators to produce a wide range of arbitrary waveforms. The compatibility of EDA and test instrumentation (available from Agilent Technologies) allows designers to leverage encryption algorithms, to leverage connectivity algorithms between the EDA environment and the test bench, to share signal-generation code, and to support two-way communications between simulators and analysis tools, such as BER testers and vector-network analyzers (VNAs).

This "connected-solution" approach allows virtual prototyping where a new WLAN design can be tested with existing components, by exporting simulated signals to test hardware inputs and then pulling the test hardware outputs back into the simulator for processing. The approach also makes it possible to emulate the behavior of a WLAN hardware block by importing signals from a hardware output, processing the signals in the simulator environment, and exporting the resulting processed signal back to a hardware input. It also simplifies debugging and troubleshooting of designs and makes it possible to create custom test beds for evaluating the performance of new designs.

Upon successful functional block/system verification, a system design is nearly complete. Lower-level layout floorplanning, synthesis, timing and baseband implementation have been brought to the physical-design step. After fabrication, the system designer can use the embedded IP and test vectors generated within Agilent Ptolemy, plugging them into a connected solution for hardware verification and prototype testing. For more information visit www.agilent.com/find/eesof. MRF

Perfect LNA performance for typical CDMA applications

WHEN NEW TECHNOLOGIES, such as digital communications, were introduced, the requirements for composite amplifiers that met particular design goals that were not satisfied by previously available standard designs were increased. In the past, there have been a trio of distinct and generally incompatible basic design approaches that have satisfied the requirements of most design goals for small-signal amplifiers: the high-gain, low-return-loss, conjugately matched amplifier; the low-noise amplifier (LNA); and the high-output power amplifier (PA). An application note entitled, "Optimizing LNA Performance for CDMA Application Using Nonlinear Simulator" from California Eastern Laboratories (Santa Clara, CA) focuses on the improved performance of the original LNA for personal communications services (PCS) by using a range of feedback techniques and predicting the system performance on the digital signal through nonlinear simulation analysis. While the designs that the application note provides may not offer the ultimate design solutions for every PCS application, it does introduce a few important RF and microwave techniques that are applicable to many digital applications.

The note demonstrates an LNA design at 1.9 GHz using the model AN1039 gallium-arsenide (GaAs) pseudomorphic high-electron-mobility transistor (PHEMT) that is programmed for mobile applications, specifically those with a code-division-multiple-access (CDMA) input signal. The note provides the required performance specifications, along with simulation and test results. The inductive-series-feedback technique was explained and demonstrated using Xpedion's design suite, which was employed to foresee and optimize the LNA performance for gain, noise, and adjacent-channel-power-ratio (ACPR) performance. Finally, functionalized measured results were logged and resulted in an LNA that satisfied all the specification goals for a typical CDMA application. This application note is available as a free download from the company's website.

California Eastern Laboratories, 4590 Patrick Henry Dr., Santa Clara, CA 95054-1817; (408) 988-3500, FAX: (408) 988-0279, Internet: www.cel.com.

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Applications that require an "all-off" state can be implemented with the addition of a simple biasing circuit that can be added at any one of the RF ports.

Create an "all-off" state for a DPDT switch

MODEL HMC436MS8G IS a low-cost, C-band dual-pole, double-throw (DPDT) switch that is the subject of an application note entitled, "Simple Bias Circuit Creates All-Off State For HMC436MS8G" from Hittite Microwave Corp. (Chelmsford, MA). The unit operates between 4.9 and 5.9 GHz and can be used as an integrated-antenna-diversity and transmit/receive (T/R) switch for the 802.11a/HiperLAN and Unlicensed National Information Infrastructure (UNII) radio platforms. The design provides 20 dB of isolation between antennas, as well as between transmitter (Tx) and receiver (Rx) ports.The switch features 1-dB insertion loss and high-power-handling capability. Switch state is controlled using four control-voltage lines toggled between 0 and +3 to +5 VDC.

In normal operation, there is always one "on" path and, therefore, two of the control lines are high, while the others are low. For the switch to operate properly, there must be at least one high-level control line to bias the switch. Without any high-level control lines, it would be impossible to pinch off the switch field-effect transistors (FETs) in the channels that the user wants to turn off. Applications that require an "all-off" state can be implemented with the addition of a simple biasing circuit that can be added at any one of the RF ports. Adding a simple bias circuit to one of the RF ports on the HMC436MS8G switch will enable the user to simultaneously turn off all of the RF ports. The resulting isolation performance is greater than 15 dB at the low end of the switch-operating frequency to more than 40 dB at the high end of the band. Due to the small control current involved (125 µA total), this traditional biasing can use a relatively large series resistor, providing additional isolation from the DC circuit. This note is available as a free download from the company's website.

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cover story

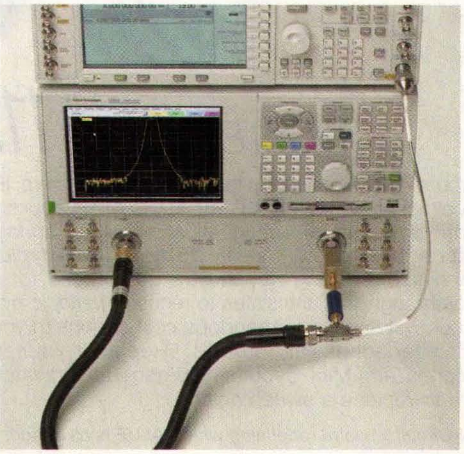
Network Analyzers Simplify Mixer Test

By offering coverage through 67 GHz and a new method for characterizing mixers, these analyzers eliminate many measurement challenges for higher-frequency designs.

Mixers are one of the fundamental components of every superheterodyne receiver (Rx), but evaluating them has never been easy, even with powerful vector-network analyzers (VNAs). The techniques employed to characterize the phase and group-delay performance of mixers are especially cumbersome, lengthy, and prone to error. To solve this problem, Agilent Technologies (Santa Rosa, CA) has created new calibration techniques for its PNA Series of VNAs that reduces or eliminates traditional problems inherent in characterization of mixers and converters. It is available for the E8362B, E8363B, and E8364B VNAs, with coverage from 10 MHz to 20, 40, and 50 GHz, respectively, as well as for the new E8361A network analyzer with coverage from 10 MHz to 67 GHz.

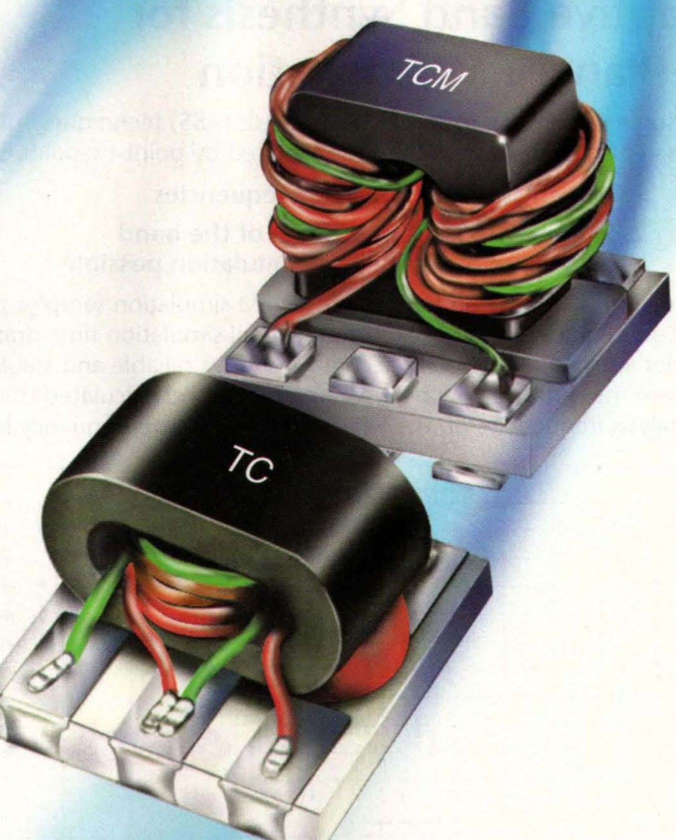
DAVID BALLO
Product Manager
Agilent Technologies, 1400 Fountaingrove Pkwy., Santa Rosa, CA 95403; (707) 577-2000, FAX: (707) 577-6070, e-mail: david_ballo@agilent.com, Internet: www.agilent.com.

The 67-GHz E8361A **(Fig. 1)** should find a following in manufacturers of passive components and subsystems designed for satellite communications, point-to-point digital radio, broadband wireless access, and OC-768 (40 Gb/s) optical-communications systems. The instrument has all of the features and capabilities of previous PNA Series analyzers, including trace noise of less than 0.03 dB at a 1-kHz bandwidth, dynamic range greater than 90 dB at 67 GHz, and measurement speed of less than 26 μs per point. Similar to all of the PNA Series instruments, the E8361A is based on the Windows 2000 operating system,



1. With 67-GHz capability, the E8361A PNA Series VNA is well-equipped for evaluating a wide range of microwave and millimeter-wave components.

RF TRANSFORMERS



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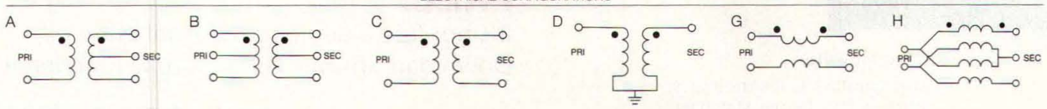
TCML1-11	1G	600-1100	700-1000	1.09
TCML1-19	1G	800-1900	900-1400	1.09
TCM2-1T	2A	3-300	3-300	1.09
TCM3-1T	3A	2-500	5-300	1.09
TTCM4-4	4B	0.5-400	5-100	1.29
TCM4-1W	4A	3-800	10-100	.99
TCM4-6T	4A	1.5-600	3-350	1.19
TCM4-14	4A	200-1400	800-1000	1.09
TCM4-19	4H	10-1900	30-700	1.09
TCM4-25	4H	500-2500	750-1200	1.09
TCM8-1	8A	2-500	10-100	.99
TCM9-1	9A	2-280	5-100	1.19

CERAMIC CASE

Model	Ω Ratio & Config.	Freq. (MHz)	Ins. Loss❖ 1dB (MHz)	Price $ea. (qty. 100)
TC1-1T	1A	0.4-500	1-100	1.19
TC1-1	1C	1.5-500	5-350	1.19
TC1-15	1C	800-1500	800-1500	1.29
TC1.5-1	1.5D	.5-2200	2-1100	1.59
TC2-1T	2A	3-300	3-300	1.29
TC3-1T	3A	5-300	5-300	1.29
TC4-1T	4A	.5-300	1.5-100	1.19
TC4-1W	4A	3-800	10-100	1.19
TC4-14	4A	200-1400	800-1100	1.29
TC8-1	8A	2-500	10-100	1.19
TC9-1	9A	2-200	5-40	1.29
TC16-1T	16A	20-300	50-150	1.59
TC4-11	50/12.5D	2-1100	5-700	1.59
TC9-1-75	75/8D	0.3-475	0.9-370	1.59

Dimensions (LxW): TCM .15" x .16" TC .15" x .15" ❖Referenced to midband loss.

ELECTRICAL CONFIGURATIONS



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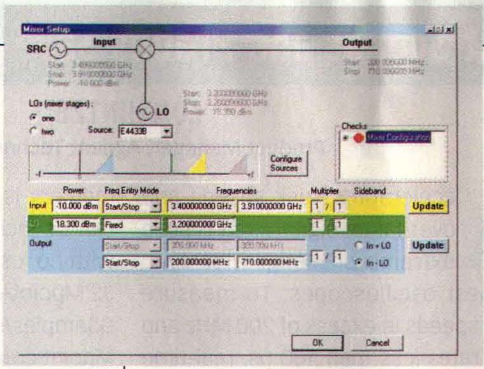
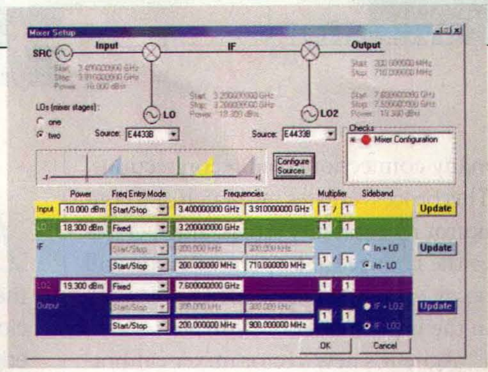




2. The dialog box for single-conversion devices (a) and dual-conversion devices (b) allows the user to enter all values in a single place, guided by the instrument to ensure compliance with acceptable limits.

which provides the operator with a familiar operating environment, provides a multitude of connectivity choices, and allows programs to be run inside or outside the analyzer.

The frequency-offset measurement capability is implemented as a hardware and firmware solution in the analyzers. The hardware provides the ability to make basic offset-frequency measurements, including mixer-conversion loss, intermodulation distortion (IMD), and harmonic and spurious responses. The firmware automates the mixer-measurement process, making it possible for users without extensive knowledge of mixer measurement to set up, calibrate, and characterize their devices accurately and quickly. The firmware's advanced calibration choices include vector correction of conversion loss, phase, and group delay, and match-corrected absolute-power measurements, both of which increase the overall accuracy of the process compared to other methods in use today.

The frequency-offset measurement capability is implemented as a hardware and firmware solution in the analyzers.

Any mixer-based superheterodyne receiving system requires that the mixers within it have well-controlled amplitude phase, and group-delay responses. Characterizing the amplitude response (conversion gain or loss) is the easiest measurement. Conversion phase and group delay, however, continue to be difficult to measure with high accuracy and repeatability, and the test set-up employed in the process usually requires multiple external components, with

many connections and reconnections. This process creates mismatch and connector repeatability errors, and increases the chance that operator error will occur, creating a high level of uncertainty in the measurement results.

Agilent's new vector mixer calibration accommodates conversion loss as well as phase and group delay, resulting in a far more accurate and comparatively simple technique that requires fewer external components and connections. This is best understood by comparing it with two other methods that are commonly employed to characterize mixer phase or group-delay responses.

The first method requires the designer to make three measurements on three pairs of mixers. The amplitude and

Agilent's new vector mixer calibration accommodates conversion loss as well as phase and group delay, resulting in a far more accurate and comparatively simple technique.

phase responses of each mixer are calculated by solving the three linear equations created by the three measurements. The technique uses upconversion and downconversion and employs an intermediate-frequency (IF) filter between the mixer pairs to keep the unwanted mixing product from being reconverted. The method also assumes that at least one of the mixers is reciprocal (it has the same conversion loss and group delay in upconversion as downconversion). Its most obvious drawback is the fact that three sets of measurements must be made and the mixer pairs must be reconnected with the filter. Errors can creep into the process due to connector repeatability and the mismatch effects between the filter and mixer pairs, as well as between the mixers and test equipment.

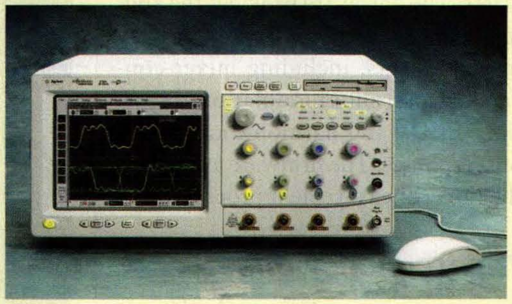
Fast Scopes and Probes Save Signal Integrity

LON HINTZE
Product Manager, Agilent Technologies

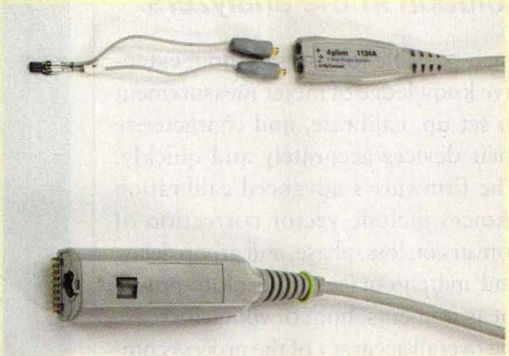
Accelerating clock speeds and ever-faster digital circuits pose extreme challenges for even the best oscilloscopes. To measure clock speeds in excess of 200 MHz and edge rates less than 100 ps, real-time oscilloscopes must have extremely high sampling rates, broad bandwidths, and must be complemented by single-ended and differential active probes with comparable performance. Fast scopes have been available, but high-performance probes have been scarce. Fortunately, the new 6-GHz model 54855A and 4-GHz model 54854A Infinium oscilloscopes and a novel probe architecture known as InfiniiMax from Agilent Technologies (Colorado Springs, CO) effectively address these challenges, delivering sampling rates to 20 GSamples/s simultaneously on four independent channels.

The probes feature a new architecture to ensure full bandwidth even when accessories are used at the probe tip to make the physical connection to the device under test (DUT). Probe amplifiers can be configured for single-ended or differential operation through different probe heads, so a single probe amplifier can be used to make either type of measurement. The two new oscilloscopes **(Fig. 1)** retain all of the features of other Infinium models, including an 8.4-in. (21.34-cm) thin-film-transistor (TFT) color liquid-crystal-display (LCD) screen, 10/100 local-area-network (LAN) Ethernet interface, 10-Gb hard drive, and remote operability from the Internet. However, the operating system has been upgraded to Windows XP, a compact-disc-read/write (CD-RW) drive has been added and there is dual-monitor support for running third-party applications on the oscilloscope. Standard memory is 262 kpoint/channel, which can be increased to 1 Mpoint/channel with no loss of sampling rate, or up to 32 Mpoint/channel at sample rates of 2 GSamples/s and slower. Memory of 1 Mpoint creates a time-capture window of 50 μs per channel at 20 GSamples/s, which is more than adequate for most applications. Acquisition memory of 32 Mpoints at 2 GSamples/s and slower sample rates allows the designer to capture long time windows at high resolution, such as identifying glitches due to a power-supply start-up from reset.

The ability to maintain a full 20 GSamples/s on all four channels simultaneously when performing either single-ended or differential measurements is unique to the new scopes. All other four-channel scopes require two channels to deliver real-time, full-rate sampling at 6 GHz without aliasing, essentially turning them into two-channel



1. The 4-GHz model 54854A and 6-GHz model 54855A Infinium digital oscilloscopes provide sampling rates to 20 GSamples/s simultaneously on four independent channels.



2. The InfiniiMax probe system is designed to provide maximum measurement bandwidth when used with the latest 4- and 6-GHz Infinium digital oscilloscope models.

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Gali 1	DC-8000	12.7	11.8	±0.5	12.2	4.5	27	108	40	3.4	.99
Gali 21	DC-8000	14.3	13.1	±0.6	12.6	4.0	27	128	40	3.5	.99
Gali 2	DC-8000	16.2	14.8	±0.7	12.9	4.6	27	101	40	3.5	.99
Gali 33	DC-4000	19.3	17.5	±0.9	13.4	3.9	28	110	40	4.3	.99
Gali 3	DC-3000	22.4	19.1	±1.7	12.5	3.5	25	127	35	3.3	.99
• Gali 6F	DC-4000	12.1	11.6	±0.3	15.8	4.5	35.5	93	50	4.8	1.29
• Gali 4F	DC-4000	14.3	13.4	±0.5	15.3	4.0	32	93	50	4.4	1.29
• Gali 51F	DC-4000	18.0	15.9	±1.0	15.9	3.5	32	78	50	4.4	1.29
• Gali 5F	DC-4000	20.4	17.4	±1.5	15.7	3.5	31.5	103	50	4.3	1.29
• Gali 55	DC-4000	21.9	18.5	±1.7	15.0	3.3	28.5	100	50	4.3	1.29
• Gali 52	DC-2000	22.9	17.8	±2.5	15.5	2.7	32	85	50	4.4	1.29
• Gali S66	DC-3000	22	17.3	±2.4	2.8	2.7	18	136	16	3.5	.99
Gali 6	DC-4000	12.2	11.8	±0.3	18.2	4.5	35.5	93	70	5.0	1.49
Gali 4	DC-4000	14.4	13.5	±0.5	17.5	4.0	34	93	65	4.6	1.49
Gali 51	DC-4000	18.1	16.1	±1.0	18.0	3.5	35	78	65	4.5	1.49
Gali 5	DC-4000	20.6	17.5	±1.6	18.0	3.5	35	103	65	4.4	1.49

■ Low frequency cutoff determined by external coupling capacitors. † Measured in test fixture P/N 90-6-20-26.
▲Models tested at 2GHz except Gali 4, 5, 6, 51, 52, 6F, 4F, 51F, 5F at 1GHz.
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The other popular method used for characterizing mixer group delay involves measuring mixer return loss with an air line that is terminated with a short, and taking the time-domain transform of the response. The time delay of the response with the short is subtracted from the delay due to the length of the air-line by itself, which yields the two-way delay of the mixer. This technique has proven useful only for broadband mixers, and delay resolution is limited by the time-domain resolution. In addition, the delay response is a combination of the response from the sum and difference products, and the measurement requires a reciprocal mixer. On the positive side, the technique does not require additional mixers or locking the local oscillator (LO) to any of the test signals.

Agilent's technique for the PNA Series analyzers is a vector-corrected mixer calibration approach that employs reflection measurements to fully characterize a reciprocal calibration mixer/filter pair, without any additional mixers. This calibration mixer/filter pair is then used in conjunction with short, open, load, and through standards to calibrate a test system that can then be used to measure the conversion loss, conversion phase, and absolute group delay of any mixer or converter under test. The method can be used to measure both reciprocal or nonreciprocal mixers and converters, and the calibration process and control of external test equipment [such as signal sources for the LOs of the device under test (DUTs)] is highly automated.

Previously, in addition to the tedious nature of the mixer-characterization process, the instrument interface from which the designer must work has typically added to the confusion of an already-difficult task. To remedy this, Agilent's new frequency-conversion firmware presents a clear picture without requiring the user to enter obscure and confusing values. All values are set up on a single screen. By entering values into a single dialog box (shown in **Fig. 2a** for single-conversion devices and **Fig. 2b** for dual-conversion devices),

instruments. The independent channels provide an important advantage, since in many measurement situations at least three signals must be viewed in relationship to each other to accurately determine performance margins.

In addition to the scopes and probes, Agilent has introduced an optional jitter-analysis package that will be useful for designers of high-speed clock circuits. It is integrated into the scope-application suite, and includes a setup wizard that guides the user through the jitter-measurement process, including tips on the various types of measurements and when to use them. Measurements include cycle-to-cycle, n-cycle jitter, and period jitter, as well as time-interval error, setup and hold time, measurement histograms, trending, and jitter spectrum.

While the bandwidth and sampling rates of the 54855A and 54854A are impressive, the use of a conventional probe architecture would have made these specifications almost meaningless. This is because the performance of traditional active probes drops precipitously at high frequencies as wire accessories are added to the probe tips to facilitate physical connection to the circuit. For example, a 2-in. (5.08-cm) long wire attached to the end of a probe with specified 6-GHz bandwidth will reduce the probe's effective bandwidth to only 1.5 GHz, rendering any additional scope bandwidth useless. In addition, as the maximum operating frequency of the probe increases, the size of the probe decreases, which can make it extremely difficult to use when "browsing" by hand from point to point in the circuit.

The new InfiniiMax architecture eliminates these drawbacks. In a conventional active probe, a length of transmission line in the measurement path (such as the aforementioned wire accessories) becomes a tank circuit at high frequencies that can resonate causing unwanted oscillation, variations in impedance, and reduced bandwidth. In contrast, the transmission line in the InfiniiMax probe circuit path is well-controlled, properly terminated, and compensated by the probe amplifier.

As a result, the InfiniiMax probe system (**Fig. 2**) offers the highest performance available for any use model—browsing, solder-in, socket or probe holder. To maintain usability of these small probes, Agilent has designed a sleeve that fits over the probe head, making it easier to hold for long periods of time in a "browsing" fashion. The company offers a considerable number of probe choices to meet customer needs ranging from low cost to the highest performance. Probe amplifiers with 3.5-, 5.0-, and 7.0-GHz bandwidths are available. Combined with "connectivity kits," these probes are capable of either single-ended or differential measurements, or both if two types of kits are selected. The kits contain a small browser (and sleeve), a socketed probe head, a solder-in probe head, and fully characterized performance plots for all of its various probe heads. These performance plots include swept-frequency response, common-mode rejection versus frequency, impedance versus frequency, time-domain probe loading, and time-domain probe tracking.

The InfiniiMax probe architecture circumvents issues that have plagued active probes for years. Since conventional probe designs have not been able to keep pace with bandwidth requirements, they have limited performance of even the fastest scopes to the maximum speed of the probe itself. In addition, these probes cannot achieve their specified performance when any wire accessory is attached to them, a situation that worsens rapidly as wire length is increased. Finally, as measurement frequencies have increased, probe designs have become smaller and smaller, which has made the probe difficult to hold. This is compounded by the task of inserting probes into the fine-pitch geometries of integrated circuits (ICs). All of these problems are successfully addressed by the new InfiniiMax architecture. P&A: 54854A (4 GHz) $49,995.00, 54855A (6 GHz) $58,995.00, InfiniiMax probes $3850.00 to $8550.00, Jitter Analysis Software $3995.00. **Agilent Technologies, (395 Page Mill Rd., Palo Alto, CA 94303, (800) 452-4844, www.agilent.com.**

all the values are presented in a single place. The firmware ensures the values are within acceptable ranges and provides help when requested.

The vector-mixer-calibration technique is conducted in two steps. The user characterizes a mixer/filter pair with reciprocal properties first, and this mixer then becomes an additional through standard with which to calibrate the test system. With this step completed, the test system can characterize nearly any reciprocal or nonreciprocal mixer or converter without the need for reconnection of the calibration mixer. Information is also provided about the input and output match of the calibration mixer, which can be used to remove mismatch errors at the input and output of the test system. Since there is no need for multiple mixer connections during the mixer-calibration process, connector repeatability is eliminated as a source of measurement error.

Measurement systems that use traditional techniques for measuring group delay are inherently not well-matched, requiring generous use of attenuators to reduce mismatches of the test system. These attenuators cause serious degradation of the test system's dynamic range and calibration stability. Until the introduction of Agilent's vector-mixer-calibration technique, no method had been proposed to correct for the calibration or reference mixer's input and output mismatch, and thus they have been impossible to determine. The vector-calibration technique is currently one of the only commercially available methods that corrects for input- and output-mismatch effects of the entire test system, providing accurate transmission and reflection measurements of the mixer or converter under test.

To show the viability of the technique, a classic network-analyzer procedure can be used. In this process, a mixer is measured by itself and then with an air line, which is a low-loss, well-matched delay line. In an ideal measurement, the test system should show the conversion loss of the mixer reduced by exactly the loss of the air line, and mismatch effects should introduce minimal ripple on the measurements. The results of measurements performed with an air line scalar and vector calibrations show that ripple in the scalar measurement is nearly an order of magnitude greater than that of the vector-calibrated measurement. P&A: $139,000.00 (E8361A 67-GHz PNA Series VNA), $19,500.00 (frequency-offset measurement capability, typical mixer option configuration); now available for order. **Agilent Technologies, Test and Measurement Organization, 5301 Stevens Creek Blvd., MS 54LAK, Santa Clara, CA 95052; (800) 452-4844, Internet: www.agilent.com/find/PNA.**

Enter No. 51 at www.mwrf.com

PRODUCT technology

PC Card Contains Bluetooth Protocol Analyzer

Although it appears as a standard 16-b Type II PC card, this is a full-featured protocol analyzer that helps Bluetooth developers quickly analyze piconet performance.

JACK BROWNE
Publisher/Editor

Bluetooth is steadily gaining ground in key markets, such as personal computers (PCs) and computer peripherals. For developers hoping to compete in these and other personal wireless-connectivity applications, the Merlin Mobile Bluetooth protocol analyzer from Computer Access Technology Corp. (Santa Clara, CA) may be their most invaluable tool. This unlikely looking precision test instrument fits into a standard 16-b Type II PC card. Yet it is a full-featured Bluetooth protocol analyzer qualified to Version 1.1 of the Bluetooth standard for piconet protocol testing. Based on the company's larger Merlin protocol analyzer, Merlin Mobile can fit unobtrusively within a Bluetooth piconet, capturing data but without interfering with the operation of the 2.4-GHz piconet. The analyzer displays packets in a hierarchical view, showing all layers of a particular Bluetooth transaction.

The Merlin Mobile measures just 5.3 × 2.1 × 0.4 in. (135 × 54 × 10.5 mm) and weighs only 2 oz. (57 g). It is supplied with a dipole antenna designed for use at 2.4 GHz **(see figure)**, which can be removed for wired connections.

The protocol analyzer employs what the company calls an "air probe" radio interface that allows users to capture and analyze Bluetooth traffic broadcast within a piconet. It can evaluate baseband, LMP, L2CAP, SDP, RECOMM, TCS, and OBEX layers of the Bluetooth protocol stack. It can also provide decoding functions for HDLC, PPP, BNEP, HID, and AT commands, or create custom decoding functions.

An operator simply loads the Merlin Mobile's software into their laptop or PC, then plugs the Bluetooth protocol-analyzer PC card into the appropriate slot on the computer. The analyzer features sophisticated programmable real-time triggering functions and advanced filtering to isolate events of interest from crowded traffic. The display software operates independently of the analyzer hardware, allowing multiple users to evaluate traces. The software works with MS Windows 98, Millennium Edition (ME), 2000, and XP.

Merlin Mobile supports point-to-point and point-to-multipoint piconets. Its precise counter/timer circuitry allows time stamping of events with 100-ns resolution. The radio portion complies with Class 2 operation [+4-dBm transmit power and –70 dBm receiver (Rx) sensitivity]. **Computer Access Technology Corp., 2403 Walsh Ave., Santa Clara, CA 95051-1302; (800) 909-2282, (408) 653-1262, FAX: (408) 727-6622, Internet: www.catc.com.**
Enter No. 52 at www.mwrf.com

The Merlin Mobile Bluetooth protocol analyzer is a portable, low-cost test solution that fits into a compact PC Card.

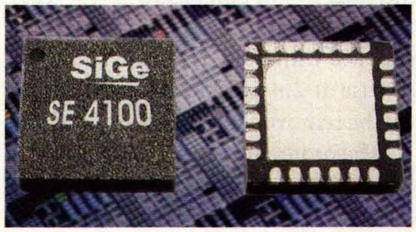
GPS Receiver IC Offers Embedded Solution

This highly integrated SiGe receiver IC is suitable for applications requiring the addition of GPS capability without significant added cost and power consumption.

JACK BROWNE
Publisher/Editor

Global Positioning System (GPS) receivers (Rxs) can now be found in many rental cars as well as in high-performance consumer vehicles. And with the availability, low cost, and small size of the PointCharger model SE4100 GPS Rx integrated circuit (IC) from SiGe Semiconductor (Ottawa, Ontario, Canada), GPS Rxs are being integrated into a wide range of electronic devices, including cellular telephones and personal digital assistants (PDAs).

The SE4100 Rx IC **(see figure)** is the first product in the company's new line of PointCharger GPS devices. It integrates an intermediate-frequency (IF) filter, voltage-controlled oscillator (VCO), oscillator tank circuitry, low-noise amplifier (LNA), phase-locked loop (PLL), and crystal oscillator within a 24-pin LPCC package measuring only 4 × 4 mm. Based on the company's silicon-germanium (SiGe) technology, the Rx shaves current consumption to less than 10-mA current for a voltage source of +2.7 VDC. The SE4100 is designed for voltage supplies of +2.7 to +3.6 VDC.



The SE4100 GPS Rx IC features a high level of integration based on an advanced SiGe process for low-power consumption and little need for external components.

The SE4100 GPS Rx IC operates at the GPS receive frequency of 1575.42 MHz and requires a reference frequency of 16.368 MHz. The chip provides a digital 4.092-MHz output suitable for GPS baseband ICs. The company offers a GPS reference design based on the SE4100 and the ST20-GP7 baseband controller from ST Microelectronics; the system's total power consumption is less than 120 mW.

The low current and power consumption of the SE4100 makes it suitable for covert and always-on applications. When all circuits are inactive, the Rx IC draws leakage current of only 10 μA, allowing for long storage lifetimes with battery-operated devices. The Rx IC also includes an antenna detect function that can alert a user to a missing or shorted antenna. P&A: $3.50 (10,000 qty); stock. **SiGe Semiconductor, Inc., 2680 Queensview Dr., Ottawa, Ontario K2B 8J9, Canada; (877) 602-7443, (613) 820-9244, FAX: (613) 820-4933, e-mail: info@sige.com, Internet: www.sige.com.**

Enter No. 53 at www.mwrf.com.

Push-On Connectors Make Links To 65 GHz

This line of easy-to-use push-on-style coaxial connectors is suitable for millimeter-wave and 40-Gb/s optical applications requiring low distortion.

JACK BROWNE
Publisher/Editor

Frequency coverage to 65 GHz was once considered the exclusive domain of waveguide. But the instantaneous bandwidth of a waveguide is relatively narrow (part of an octave) is limited by its physical dimensions. With refinements in coaxial connectors, however, coverage to 65 GHz was made possible many years ago by the Anritsu V Connector®. The new VP Connector line from Anritsu Co. (Morgan Hill, CA) provides push-on ease of use and easy installation with continuous frequency coverage from DC to 65 GHz.

The wide continuous bandwidth of the VP Connectors **(see figure)** makes them ideally suited for OC-192 and OC-768 optical-communications modules, as well as traditional microwave and millimeter-wave applications. The VP Connector family includes the model VP101F VP-to-semirigid-cable connector, the model VP102F VP Bullet, and the VP103F VP-VF adapter. The family features the VP shroud, a proprietary Anritsu design that integrates a glass bead into a receptacle that includes bead compensation and a snap-in feature. The VP shroud has an innovative ground lip that provides a simpler method of achieving a high-quality ground connection at the connector.

The VP series of push-on millimeter-wave connectors includes bullet and cable connectors as well as an adapter, each capable of low-return-loss operation from DC to 65 GHz.

The ground lip allows a substrate ground to be attached directly to the connector, eliminating long ground paths. The short ground path improves return-loss performance (typically better than 15 dB), especially at the upper bandedge. The integrated design of the VP Connectors helps reduce design and manufacturing costs for optical and microwave/millimeter-wave housings.

Two shroud types are available to accommodate a variety of design requirements. The models VP100BMS10, VP100BMS75, VP100BCPW, and VP100BNL are solder-in versions, while the VP100B is a screw-in type.

The VP bullet is designed with six slots in the outer conductor and four slots in the center conductor. The higher number of slots in the outer conductor reduces the insertion and extraction force to less than one-half of that required for conventional SMP connectors, helping to reduce wear when engaging and disengaging the connectors. P&A: 2 to 4 wks. **Anritsu Co., Microwave Measurements Div., 490 Jarvis Dr., Morgan Hill, CA 95037-2809; (800) ANRITSU, (408) 778-2000, FAX: (408) 778-0239, Internet: www.us.anritsu.com.**

Enter No. 55 at www.mwrf.com

Digital RF Signal Generator Breaks Down Complex Tests

This high-performance family merges a touch-panel interface with full digital, vector, and analog modulation in only a 2U rack size.

NANCY KONISH
Technology Editor

Signal generators must minimize errors while guaranteeing precision and repeatability, even on the most sensitive analog or digital receivers (Rxs). The 3410 series from IFR, Inc. (Wichita, KS) plans to meet this challenge by combining an RF-level accuracy of ±0.5 dB with a low-output VSWR specification. This family of digital RF signal generators is available in three frequency ranges: 250 kHz to 2 GHz, 3 GHz, and 4 GHz. As a result, the series can be used to test and emulate second-, third-, and fourth-generation (2G, 3G, and 4G) systems, as well as digital Private Mobile Radio, wireless local-area networks (WLANs), and Bluetooth systems.

These devices avoid the path of competing generators, which became bulky and complicated to keep up with modulation formats. The 3410 series' system architecture incorporates high-performance RF modulation in a small package. Compared to competing instruments, this series reduces the size and weight of RF signal generators by 35 to 50 percent. At the same time, the family simplifies the configuration process with its new user interface. It is the first touchscreen user interface for digital RF signal generators **(see figure)**.

With its simple and intuitive user interface, the 3410 series of RF digital signal analyzers deviates from the deeply nested menu-structure approach.

Using the external in-phase/quadrature (I/Q) inputs, the 3410 series provides an RF modulation bandwidth of up to 100 MHz. The instruments promise to achieve excellent modulation characteristics over this bandwidth and the signal generators' full frequency range by using a proprietary I/Q modulator design. Typically, the series' adjacent-channel-power (ACP) performance will be better than –68 dBC for a Third Generation Partnership Project (3GPP) frequency-division-duplexing (FDD) signal. The 3410 family's performance can therefore meet the requirements of the most exacting tests for 3G radio Rxs and power amplifiers (PAs). To reduce vector errors and ensure a low carrier leak at all operating frequencies, the modulator performance can be optimized through user-definable calibration routines.

An optional dual-channel arbitrary waveform generator (AWG) enables the 3410 series to generate digitally modulated carriers with an RF modulation bandwidth of 45 MHz. Using an interpolation filter design, the AWG operates at a high sample rate. This allows smaller files to be created, while eliminating the need for selectable hardware filtering and the associated errors introduced by it. **IFR, Inc., 10200 West York St., Wichita, KS 67215; (316) 522-4981, FAX: (316) 522-3022, www.ifrsys.com.**

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System Tests And Designs Small Antennas

THE DESKTOP ANTENNA Measurement System (DAMS) is designed to provide a method of designing and testing small to medium-sized antennas. DAMS uses state-of-the-art software to fully interact with a network analyzer, providing seamless automatic measurements with little user intervention required. The platform is controlled by the measurement software through the parallel port on the computer. The network analyzer is controlled using a general-purpose-interface-bus (GPIB) interface card that is installed on the computer. When a measurement is made, the software signals the network analyzer to make the specified measurements.

Diamond Engineering, P.O. Box 2037, Diamond Springs, CA 95619; (530) 626-3857, e-mail: mikehill@diamondeng.net, Internet: www.diamondeng.net.

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Polymers Remove Embedded Probe Debris

PROBE POLISH IS a family of polishing polymers for in-situ cleaning of rounded, radiused, and cobra-type probes. Probe Polish uses a proprietary polymer coating on a wafer or pad that mounts directly in the wafer tester. By probing the polymer coating, embedded and bonded debris is removed from the probes and trapped in the polymer to maintain probe-card cleanliness, thus improving testing accuracy by up to 2 percent. No residue remains on the probes and no contaminants escape into the environment. Probe Polish is available as polyester-backed film for all abrasion plates, wide-area polishing plates, and probe plates, or as polymer-coated wafers in all sizes up to 200 mm. P&A: $25.00 to $800.00 depending on size, application, and volume.

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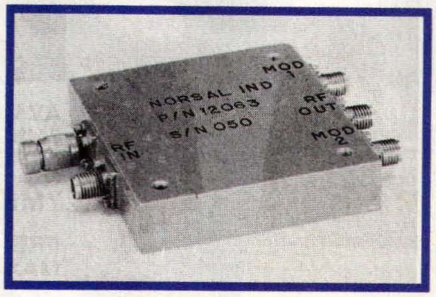

THE JULY 1982 issue included a product feature on a line of SSB modulators from Norm Spector's Norsal Industries (Central Islip, NY). The series covered frequencies from 1 to 18 GHz with IFs up to 320 MHz.

next month

Microwaves & RF November Editorial Preview

Issue Theme: Amplifiers & Oscillators

News

November will feature a close look at one of the microwave industry's most enduring companies, Weinschel Corp. Celebrating its 50th anniversary this November, the company has endured several changes in management over the years to become one of the high-quality and trusted names in precision attenuation components and subsystems. This story will interview key members of Weinschel's engineering and sales teams, and spend time with two sisters who have each contributed more than 40 years working for the company. This Special Report will examine the company philosophy and the reasons behind Weinschel's longevity, serving as a guidebook for newer companies wishing to match the accomplishment of five successful decades in the microwave industry.

Design Features

Several strong technical presentations support November's Amplifiers & Oscillators theme. Technical articles will highlight the process of selecting crystal resonators for high-performance crystal oscillators, as well as how to use low-cost buffer amplifiers in the design of stable VCOs. Designers of LNAs will benefit from an article on an integrated approach to LNA design using miniature hybrid power combiners, while wireless designers should appreciate a report on making precise RF power measurements with an integrated detection circuit.

Product Technology

The Product Technology section will highlight a new family of high-speed DACs for communications and instrumentation applications. Suitable for multicarrier signal generation in CDMA and other wireless systems, these DACs offer 12- and 16-b resolution at sampling rates to 260 MSamples/s. Additional product features will introduce a line of broadband modulator driver amplifiers for optical communications systems operating to 40-Gb/s, a 6-GHz DSO with powerful signal-processing capabilities, and a line of low-power, high-speed DSPs for wireless designs.for applications through 5 GHz, a connector system with interchangeable transition pins and tabs, a precision jitter analyzer from a leading supplier of digital oscilloscopes, and an amazing design-kit collection of 90 small-signal amplifiers and a test fixture that sells for only $10.

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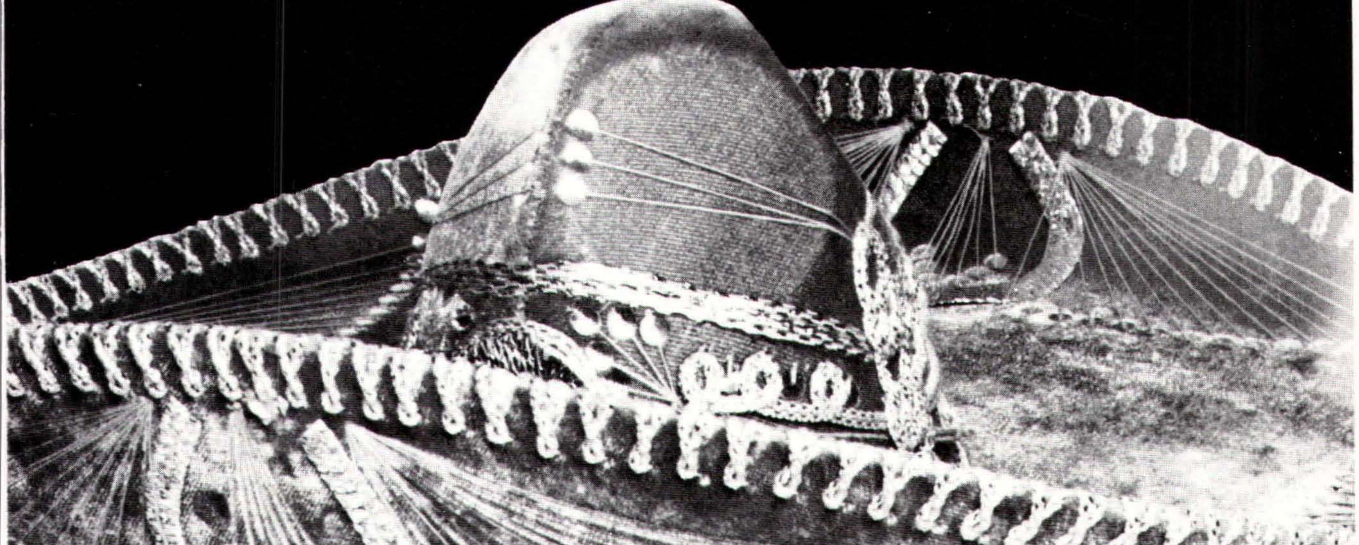

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DC-100	15	±0.3	0682-15F
DC-100	30	±0.5	0682-30F
DC-250	10	±0.5	0682-10F
Uncalibrated models			
DC-60	40	±1.0	0682-40
DC-100	20	±0.6	0682-20
DC-100	30	±0.5	0682-30
DC-200	30	±2.0	0682-30A
DC-250	15	±1.2	0682-15
DC-500	10	±0.25	0682-10

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